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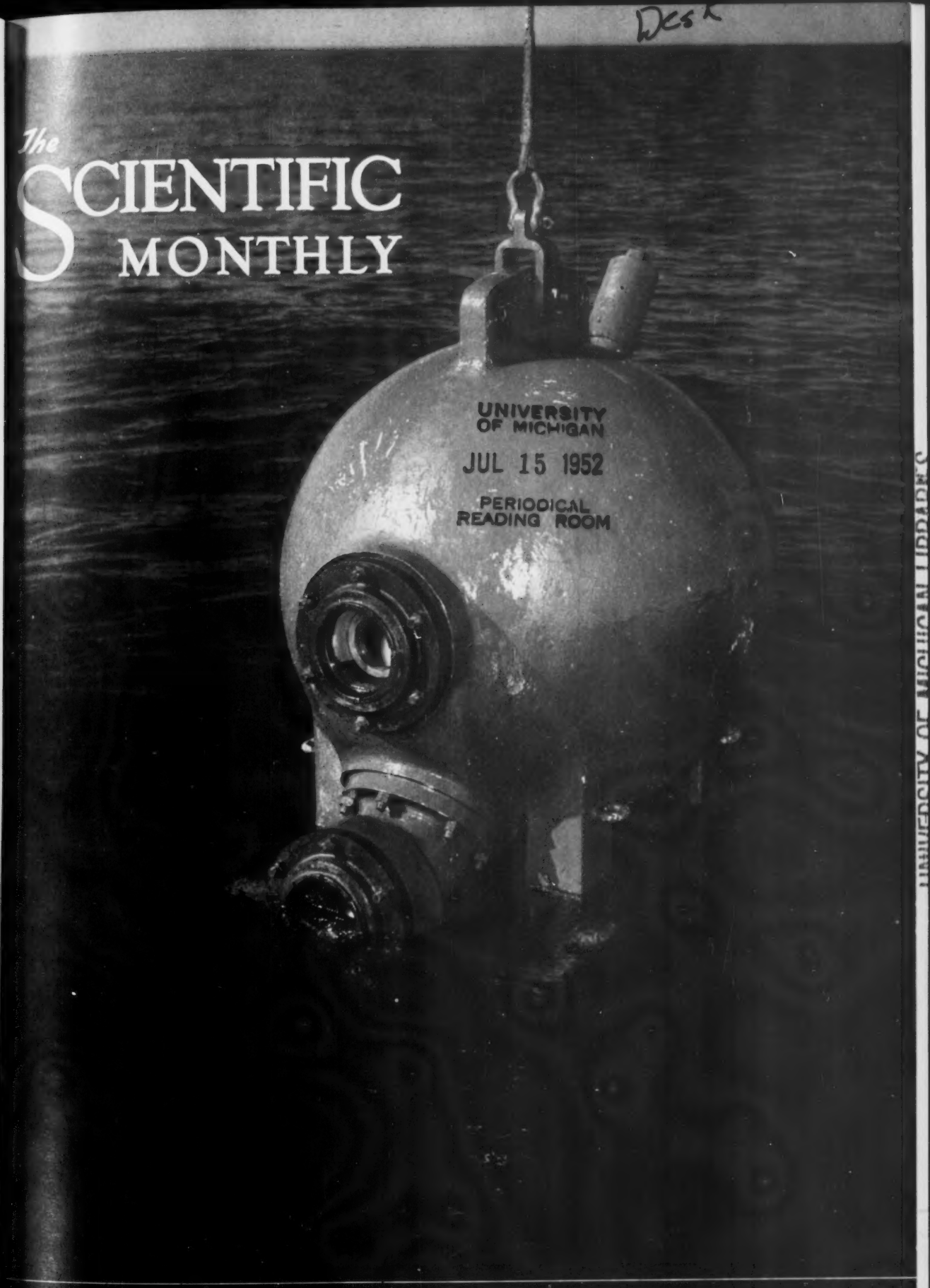

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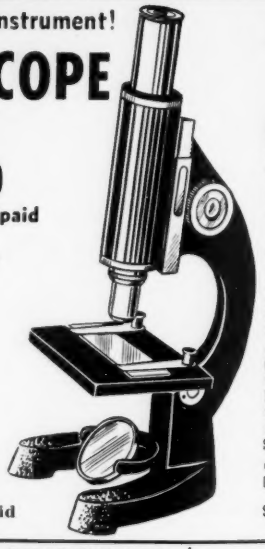

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VOL. LXXV JULY 1952 NO. 1

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(From the Month's News Releases)

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Ancient Glories

Donald E. McCown, field director of the archaeological expedition sent by the universities of Pennsylvania and Chicago to Nippur, is back with thrilling reports of fresh discoveries, which include a great temple of the Early Dynastic Period; two superimposed "cities," layer on layer, dating from the Sumerian and Babylonian periods; some 900 inscribed clay tablets, 200 of which are virtually complete; and inscribed statuary. The temple, believed to be a temple complex to gods reigning under Enlil, will be excavated in the 1953 dig. One of the group, Harry Payne Whitney, of Germantown, a graduate student of the University Museum, originated a method of cleaning ancient clay tablets by sand-blasting. It proved to be far less destructive than the old method of brushing them clean. The expedition also used rubberlin, a latex product, to make molds of the tablets so that philologists may study the inscriptions simultaneously.

No More Smashed Fingers

A nail clip that can be attached to the head of a hammer in two minutes fits most types of carpenter's hammers, will handle shingle nails or spikes, and can be used either right- or left-handed. It allows free use of one hand while starting a nail and gives a hammer's length of extra reach.

By Whatever Name

BARK, the first Swedish binary-type computing machine, will be used to make more accurate weather forecasts. A group led by Carl-Gustaf Rossby, who has returned to Sweden from the University of Chicago, is at work on the problem under the auspices of Unesco. Under construction is BESK, with a memory unit that will retain 4000 twelve-digit numbers.

DINA, which will store 400,000 binary digits, is still to be built. Cornelius Leondes and Morris Rubinoff, of the University of Pennsylvania, outlined their plans for it in a technical paper read at the annual meeting of the American Institute of Electrical Engineers in Minneapolis last month. According to the two scientists, it will not be necessary to program problems for DINA, which will be faster and smaller than most electronic digital computers.

At the Institute for Advanced Study a new, but unnamed machine, built at a cost of $1,000,000, was recently demonstrated in public for the first time. John von Neumann was head of the staff that spent six years planning and building the computer. It, too, will be employed in fast, long-range weather forecasting.

MANIAC, designed and constructed at Los Alamos, is also believed by its creators to have distinct advantages over many other big brain machines developed during the past few years. Among the best-known are ANACOM, BINAC, CALDIC, EDVAC, ENIAC, the MARKS (I, II, and III), ORDVAC, REAC, SEAC, SWAC, and TYPHOON.

Kaneelhart

The Yale School of Forestry, during a five-year tropical wood testing program, has discovered that kaneelhart (*Licaria cayennensis*) is one of the strongest and heaviest woods in the world, being five times stronger than white oak and nearly half as strong as aluminum, although it weighs only a third as much. A member of the laurel family, it is found in about 40 varieties in Central America and along the northern coast of South America. It can be machined to a mirrorlike finish. Kaneelhart cannot be grown in temperate climates.

Wide-Angle Viewer

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Two-Way Stretch

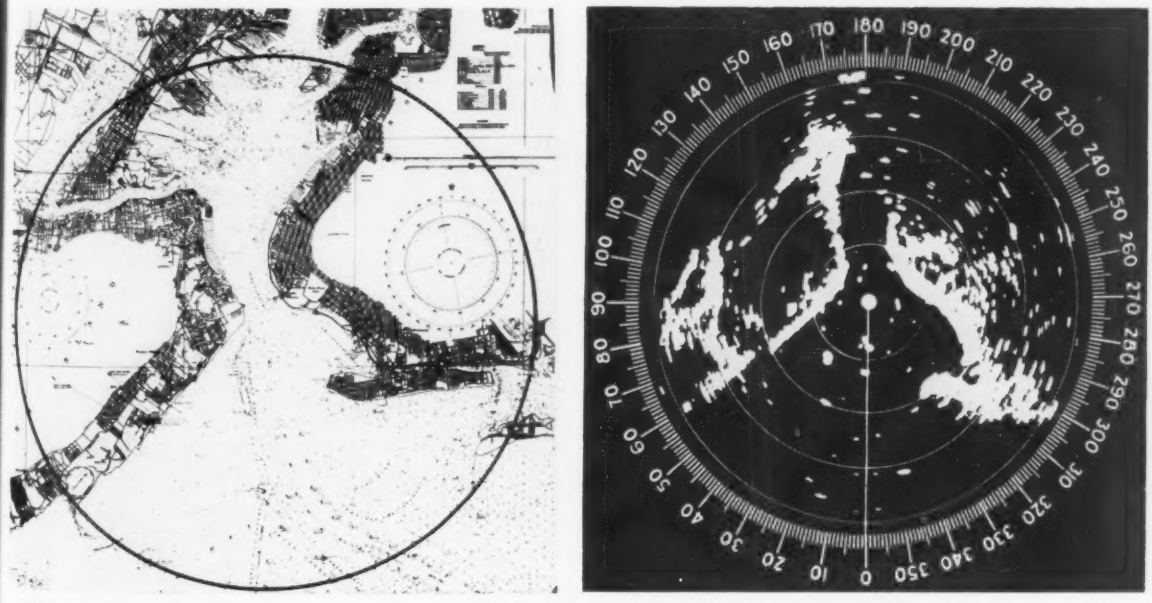
A new type of cotton bandage is elastic in both directions and flexible enough to conform readily to body contours without restricting circulation or freedom of movement. Developed during World War II by the USDA Southern Regional Research Laboratory, the bandages are now being put into commercial production.

Mender

A mending fluid that is applied like glue can be used, according to the manufacturer, on any color fabric, and is guaranteed to wash, iron, or boil.

Give 'em all B

That bane of schoolteaching, averaging grades, may soon be ended. Dwight F. Mowery, Jr., assistant professor of chemistry at Trinity College, while working number puzzles for recreation, discovered a new method of averaging numbers between 1 and 100 with a circular slide rule. He is making up a number of computers to be tried by teachers, analysts, and statisticians.



The S. S. *United States,* New flagship of the United States Lines, which sailed from New York on her maiden voyage this month, is equipped with Mariners Pathfinder radar, a gift of the Raytheon Manufacturing Company. Shown above at left is a U. S. Coast and Geodetic Survey chart of New York Harbor. Area marked with a circle is also shown in the radar picture at right, which follows the chart closely.

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4. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Manpower II, National Geographic Society, Phi Beta Kappa, RESA, Sigma Xi.
5. Details of the Kiel Auditorium, downtown hotels, Washington University.
6. Titles of the latest scientific films to be shown in the AAAS Science Theatre.
7. Exhibitors in the 1952 Annual Exposition of Science and Industry and descriptions of their exhibits.

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THE
SCIENTIFIC MONTHLY
JULY 1952

Submarine Photography with the Benthograph*

K. O. EMERY

The author, appropriately enough, was born in Swift Current, Saskatchewan. He is a U. S. citizen, however, and took his Ph.D. in geology in 1941 at the University of Illinois. He has been at the University of Southern California since 1945 and with the U. S. Geological Survey since 1946. Dr. Emery is spending the summer in the Marianas as a member of the field party that is making a detailed survey of Guam under the leadership of Joshua I. Tracey, Jr.

FOR many years man has wanted to view the bottom of the ocean for profit, adventure, and knowledge. Since earliest times pearl divers have reached depths as great as 60 feet with few or no mechanical aids. Use of flexible pressurized diving suits extended the depths to between 400 and 500 feet. Various kinds of articulated armor and of rigid hollow chambers have been developed to avoid the discomfort and danger of the water pressure on the diver's body. One of the earliest of the latter, the "photosphere," was built and used by J. E. Williams in 1913 to observe and photograph marine life and bottom scenery at depths of about 30 feet. A flexible steel tube between the sea surface and the observation chamber provided a means of entrance and an air supply. Great depths, however, can be reached only by completely enclosed units. The first one, the "bathysphere," fastened at the end of a cable, carried William Beebe and Otis Barton to a depth of 3000 feet in the Atlantic Ocean in 1934. An improved model, the "benthoscope," built by Barton and tested in collaboration with the Hancock Foundation, allowed Barton to reach 4500 feet off California in 1949. To gain mobility, Jean Piccard and M. Cosyns designed and made some inconclusive tests in 1948 of a "bathyscaphe," a manned chamber intended to operate independently of a cable, somewhat like an underwater balloon.

The use of manned devices is dangerous, expensive, and accomplishes little that instruments alone cannot accomplish better. Accordingly, there has been a parallel development of remote-controlled underwater cameras. The first really successful one was invented and used by Maurice Ewing and his associates at Woods Hole Oceanographic Institution in 1941. This camera has been used extensively in both the Atlantic and Pacific oceans to maximum depths of about 1200 feet. Subsequently, the same group made and used other models for photographing the bottom to depths as great as 18,000 feet. Variations, not generally successful, were made by other organizations between 1941 and 1949. All these cameras were single-shot devices that had to be raised to the surface between photographs. In 1950 Robert Dietz and his as-

* Contribution of the Allan Hancock Foundation.

sociates at the Navy Electronics Laboratory of San Diego built a multiple-shot camera using an electronic flash that obtained some photographs of the bottom at a depth of 4500 feet. Such a multiple-shot device not only saves hoisting time but also allows the photographer to choose the best from a series of photographs. The same objectives plus an immediate choice of subject matter were offered by an underwater television transmitter assembled by the Navy Bureau of Ships and used in 1947 at Bikini Atoll in depths of about 100 feet.

In general, the manned deep-sea chambers have been used only for observation of organisms living in the water, and the bottom has not been seen from them except by accident and then for only a fleeting moment. On the other hand, the remote-control cameras have been used chiefly to photograph the bottom and not the water above it. Realization of the limitations of manned observation chambers and of remote-control cameras led to the development by the Hancock Foundation of a new device, the "benthograph." This was aided by experience gained in handling the benthoscope. Maurice Nelles, engineering and research manager, was chiefly responsible for construction of the housing, Perry Stille and William Fortin for the instrumentation, and Captain Allan Hancock for handling procedure and shipboard experimentation.

The benthograph was designed to carry many kinds of instruments, including multiple-shot photographic equipment, to any depth of the sea except the foredeeps. Photographs of the bottom, as well as of organisms in the overlying water, were wanted. In order to avoid the complications introduced by the use of electrical cables from the surface, the unit had to be completely self-contained and thus of large internal capacity. This size, plus the presence of several windows, makes possible its future use to hold equipment for television, measurement of light intensity, and other investigations.

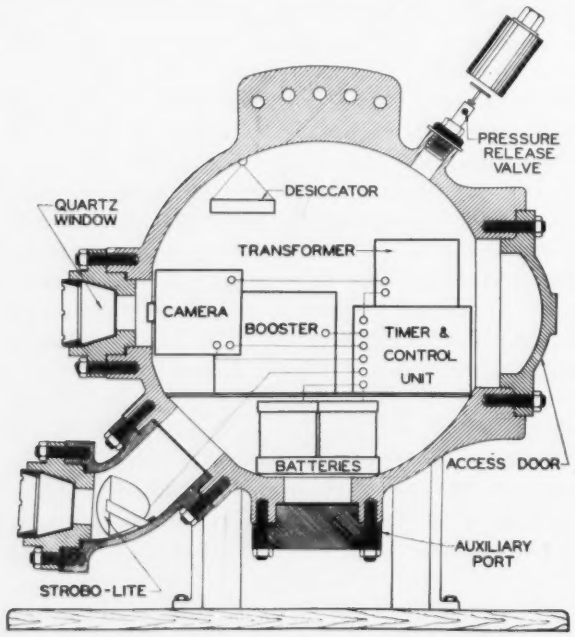


FIG. 1. Cross section of benthograph showing construction details and equipment used for photography.

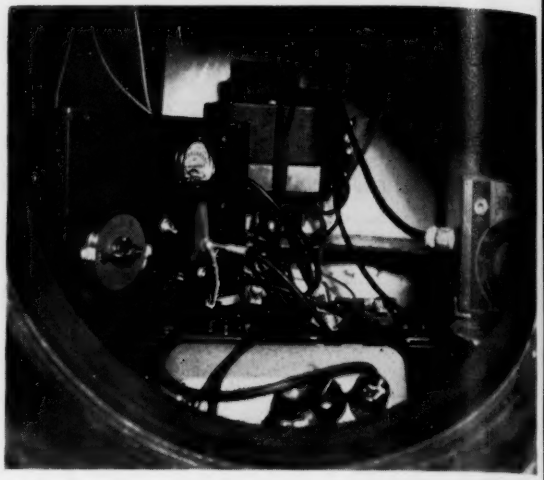


FIG. 2. View through access door of benthograph showing arrangement of photographic equipment.

Construction of the Benthograph

Housing. The water-tight housing is a hollow cast steel ball 39 inches in diameter, with walls 1½ inches thick (Fig. 1). Forming part of the casting are four legs at the bottom and a ridge with five holes for cable attachment at the top. The best general view of the sea floor is given with the cable shackled in a hole that allows the ball to tilt forward about 15°.

The ball has five openings, the largest of which is the access door (Fig. 2). This is 15 inches in diameter and is closed by a cast steel plate bolted in place and sealed by two neophrene O-rings. Three other openings are ports having windows of quartz glass 3 inches thick and 6 inches in diameter. Hollow extension arms can be inserted in the ports, and the windows moved to their outer ends. For bottom photography one port has been used for the camera, a second one with an extension arm for the light source, and the third has been closed off. The smallest opening is for a pressure release valve needed to allow entrance of air for relieving the partial vacuum produced by cooling of the air inside the ball during a dive into deep cold water.

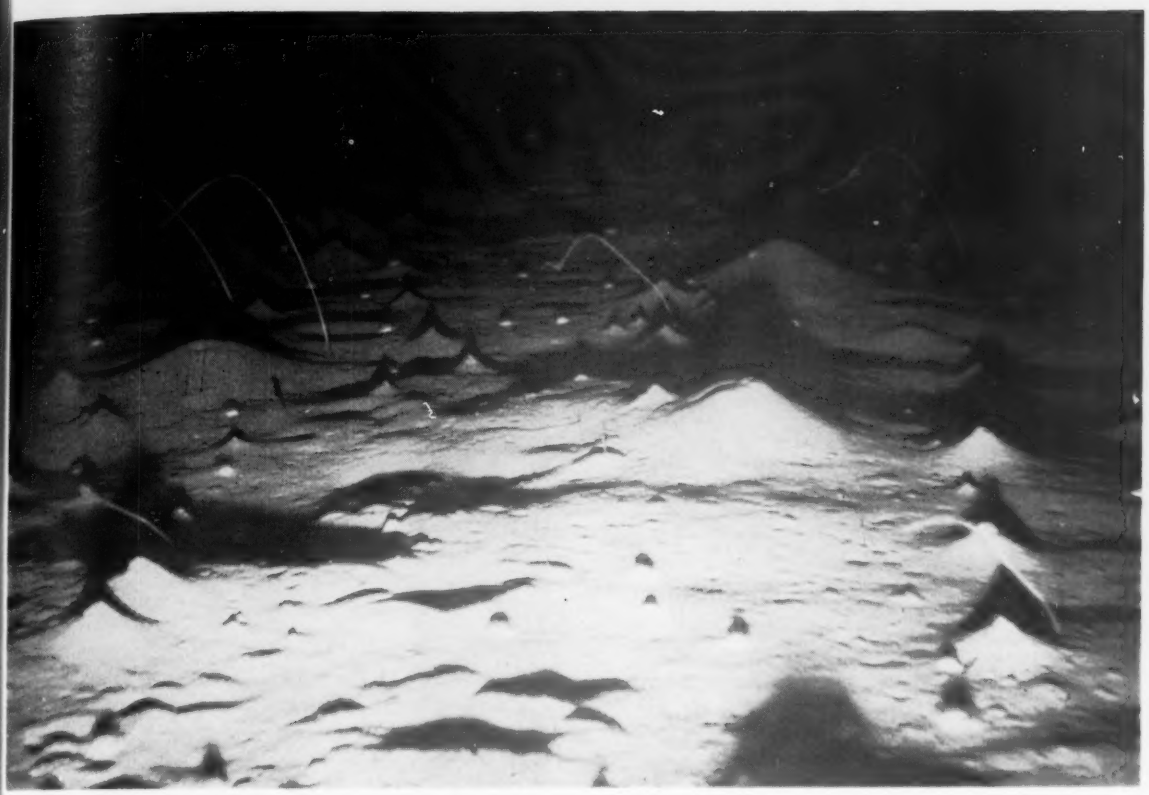


FIG. 3. Insular shelf east of Catalina Island, Lat. 33° 19.0′, Long. 118° 17.7′, 295 feet. The sediment is a foraminiferal shell sand. Burrowing organisms, probably worms, have built the conical piles of sediment at the mouths of their burrows. Note the abundant sea urchins (probably of genus *Lytechinus*) and long, curved sea-whips (probably of genus *Acanthoptilum*). Bottom edge is about 6 feet wide. (September 22, 1951.)

Until air is admitted the access door cannot be removed.

Loaded with equipment, the benthograph weighs about 3300 pounds in air and 2150 pounds in water. Lowering and hoisting are done by the *Velero IV*'s large winch, which carries about 12,000 feet of 7/16-inch nontwisting cable. The winch speed is such that about 10 minutes is required to lower the benthograph 5000 feet, and 35 minutes to hoist it back to the surface. An A-frame operated by compressed air simplifies handling between the deck and the water surface.

Camera. The camera considered the best of several tested is an electrically operated Varitron with a 91mm Ektar lens. This lens has a 28° field of view, corresponding to the field of illumination and to the diameter of the glass ports. Best results have been obtained with a setting of f. 5.6 at 1/50 second using Agfa Plus X film, and f. 4.5 for Agfa color film. When fully loaded, the camera holds 100 feet of 70mm film, permitting 325 exposures in a single lowering of the benthograph. Exposures are usually made at 30-second intervals, synchronizing with the periodic flash of the light source; thus the whole roll of film lasts more than 2½ hours. A time-delay mechanism controls the starting time of the equipment. An automatic counter that also carries the serial number of the lowering is photographed in one corner of the negative, serving as a permanent identification of the pictures.

The large size of the negatives (2½ × 3⅜ inches), together with use of a fine-grained developer, eliminates most of the effect of grain that commonly limits the use of 35mm film. Developing of both the black-and-white and the color film aboard ship shortly after exposure serves to correct errors in setting or mechanical failures, with minimum loss of ship time.

Light source. Periodic lighting is supplied by a General Electric Xenon Flashtube (FT 503) powered by a condenser that requires 30 seconds for charging by a 3300-volt power pack operated from a 110-volt transformer connected to two 6-volt automobile batteries. At this voltage the power required for the lamp is 1320 watt-seconds,

yielding about 46,200 lumen-seconds. A microswitch allows a choice of flashing intervals between 30 and 36 seconds and synchronization of the camera.

In clear water objects estimated to be about 40 feet distant are sufficiently lighted to be photographed, so for best lighting the axis of the camera is set to intersect the axis of the lamp about 20 feet from the benthograph. The short flash, about 1/500 second, apparently does not disturb fish, and it also seems to be the best way of obtaining intense illumination.

Operation

For bottom photography the benthograph is lowered rapidly to near the depth shown by the echo-sounder and then more slowly until a cable strain meter indicates that the bottom has been reached. The benthograph is then immediately raised a foot or two above the bottom so that it can tilt properly and also turn and drift slowly. This procedure allows it to cover more area and to stay clear of mud clouds raised on contact with the bottom. Where the bottom is soft and muddy, the benthograph is lowered to the bottom, raised about 100 feet to wash off mud that may cover the ports, and then lowered to within 10 feet of the bottom. Additional lowering is done by slow stages, during which photographs are taken continuously, in the expectation that the vertical movement of the benthograph owing to lifting of the ship by waves will permit some of the photographs to be taken just above the bottom. On steep slopes the benthograph is usually lowered to the base of the slope, raised 10–30 feet, held there until it is carried to the slope again by the drifting ship, when it is again raised. This stepwise procedure permits the photographing of a large portion of a slope.

Photography of organisms in the water is simpler. Photographs at various depths are taken by lowering the benthograph slowly and recording the time for each hundred-foot unit of cable paid out. The time and depth of the automatically numbered film exposures are then easily determined. The depth is later written on each negative.

Results

The sea floor off southern California is one of the best regions in the world for studies in submarine photography, because of its variety of underwater scenery and the general clearness of the water. Several million years ago a network of faults divided the region into a checkerboard of separate blocks; some of these moved upward to form islands and banks, and others moved downward to form deep basins. Wave erosion then cut shelves along the mainland shore and around the islands.

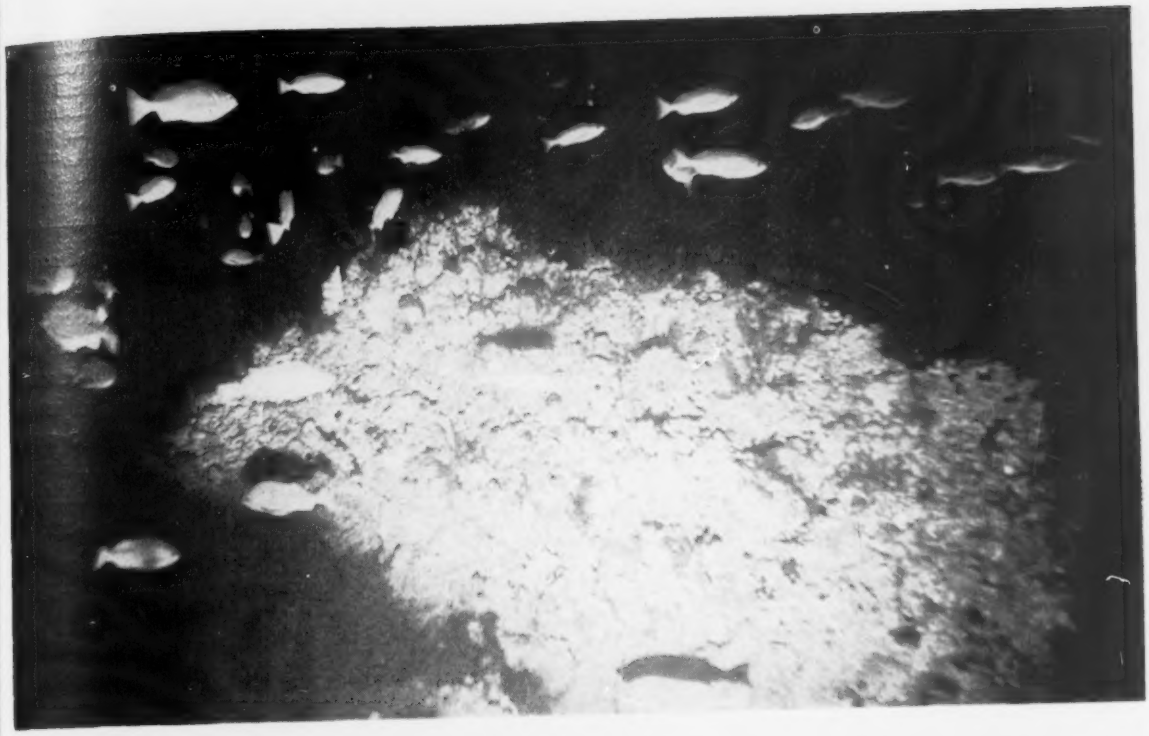
FIG. 4. Top of Osborn Bank, Lat. 33° 22.0′, Long. 119° 02.9′, 190 feet. Irregular masses of rock, covered by hydroids and encrusting organisms, project through a blanket of coarse foraminiferal glauconitic sand having abundant ripple marks. The fish above the rocks are perch. Bottom edge is about 6 feet wide. November 19, 1951. (AHF 2086.)

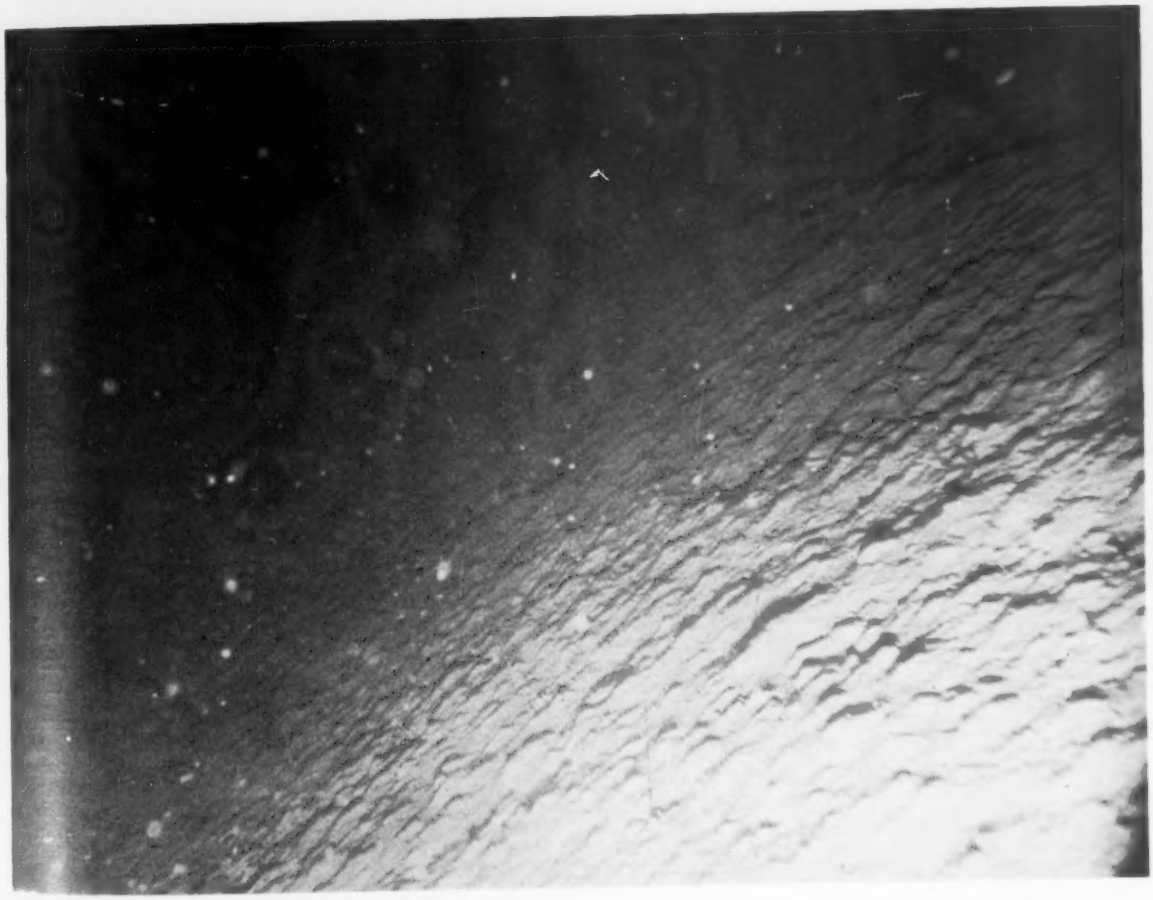
The shelf along the mainland is a quarter of a mile to fifteen miles wide and consists mostly of large areas of sand and mud with smaller zones of rocky bottom. The presence of fine sediment and of strong wave and current action causes the water to be generally too turbid for good underwater photography. The shelves around the islands have clearer water, however, because they are covered mostly by coarse shell sand, and the islands themselves contribute but little fine sediment to the water. As a result, excellent photographs can be obtained (Fig. 3). These yield information that can be obtained in no other way about the small features of the bottom such as ripple marks, trails, holes, and burrow heaps. The abundance of minor features formed by burrowing animals indicates that wave and current action is surprisingly ineffective in redistributing the sediment in some shelf areas.

Still clearer water exists over the offshore banks, where there is practically no present source of detrital sediment. Rock is dominant, and because of the clearness of the water the top surfaces of the rocks down to depths of about 300 feet are covered by organisms such as calcareous and other algae, hydroids, bryozoans, serpulid worm tubes, starfish, and brachiopods. Great numbers of polychaete worms and crustaceans inhabit the crevices between the rocks, and large schools of various kinds of fish live in the waters above the banks (Fig. 4). Sand, composed mostly of foraminiferal tests, shells, and glauconite, forms a thin patchy cover between the rocks.

Bordering the banks and shelves are slopes that lead down into the adjoining basins. These have an average steepness of about 12°, although locally they are much steeper. Dredgings show the common presence of rock and it is supposed that the sediment that is being deposited atop the rock occasionally slides down the slope, exposing the

FIG. 5. Slope south of Palos Verdes Hills, Lat. 33° 41.1′, Long. 118° 20.3′, 960 feet. Steepness estimated at 40°. Note small irregularities produced by burrowing animals and probably also by unevenness of shale bedrock. March 30, 1952. (AHF 2102.)





rock until it again becomes buried. Photographs on the slopes (Fig. 5) show minor irregularities, some of which appear to be heaps formed by burrowing animals; others are probably masses of mud resting atop small projections of bedrock.

Submarine canyons cut deeply into the slopes and usually extend several miles across the shelf above. The canyons are believed to have been formed through erosion by sediment-laden currents moving down the underwater slopes, and by streams which flowed across the present sea floor during a glacial epoch of lowered sea level about half a million years ago. Photographs of the walls of the deep outer portion of one canyon show slopes similar to those bordering the shelves. A complete photographic study of the canyons should contribute much to a knowledge of their history.

Quite a different environment is represented by the basins. These contain water that circulates so slowly that it has become nearly stagnant, having only about 2 per cent of the oxygen content of the surface water. Because of the low oxygen content, the low temperature (about 38° F.), the great depth (as much as a mile and a quarter), and the darkness, only certain specialized animals can live on or near the bottom. Nevertheless, bottom photographs (Fig. 6) show an abundant population of various kinds of worms, brittle-stars, crinoids, and holothurians. The bottom is very bumpy and irregular, evidently because of the activities of these mud-eating organisms. The bumpy appearance of the mud is contrary to the belief of many geologists that thin, evenly layered shales form in such environments. The bottom photographs are somewhat difficult to obtain, because the mud is so soft that the benthograph sinks below the mud surface, and when raised out of the bottom, it is covered with mud that sticks to the ports and blocks the light source and the camera.

Photographs taken when the benthograph is being lowered or hoisted through the water show many plants and animals. The larger plants, such as kelp and other succulent algae, are restricted to areas of shallow water. The only plants other than bacteria living in the open sea are diatoms, which are most abundant in the top hundred feet of water and are too small to be photographed without a microscope, except as light scatterers.

Most fish also live near the surface (Fig. 4) and are well-known types. At great depths, however, unusual fish are taken in trawls—fish that have become adapted to this peculiar environment by carrying their own lights, like fireflies, and that probably swim about with their enormous mouths held open to collect as much as possible of the organic debris that rains down from above. In general, these fish are so small and delicate that they become badly damaged during collection. If larger fish are present, they are either extremely rare or are able to swim away from the trawl. Photographs should be most helpful in learning of the kinds, the depth distribution, and the habits of deep-sea fish; of the more than 1000 photographs taken in deep water so far, however, none show definite deep-sea fish, testifying to their rarity or to their transparency.

FIG. 6. Bottom of Catalina Basin, Lat. 33° 22.2′, Long. 118° 47.9′, 4350 feet. Note in the right foreground the ten arms of a probable comatulid crinoid. Small worm tubes and brittle stars litter the surface. Two holothurians are present in left foreground. The very irregular bumpy surface of the fine mud evidently results from the activity of these burrowing animals. Bottom edge is about 6 feet wide. April 29, 1952. (AHS 2111.)

In contrast to fish, invertebrates of many kinds are abundant in the water. One of the most interesting concentrations of animals occurs at mid-depths. During the daytime at depths between 800 and 1500 feet there is such an abundance of animal life that a large percentage of the sound beam from a ship's echo-sounder is intercepted and reflected back to the sea surface. This echo, automatically received by the ship and drawn on the recording tape of the echo-sounder, looks so much like an echo from the bottom (and is frequently mistaken as such) that it is known as the "false bottom," or sound-scattering layer. During World War II it also was picked up by submarine acoustic detection devices of destroyers and was sometimes depth-charged. At dusk the sound-scattering layer rises nearer the surface, usually to less than 500 feet. Shortly before dawn the layer again sinks, evidently in response to increasing light intensity. Occasionally, during the daytime, the sound-scattering layer separates into as many as four thin, separate layers. It has been observed in the Atlantic, Pacific, Indian, and Antarctic oceans and in the Mediterranean and Red seas, and thus is of worldwide distribution.

Little has been learned of the composition of the sound-scattering layer. Many small crustaceans are

FIG. 7. View of water showing abundant light-scattering objects above San Nicolas Basin, Lat. 33° 04.5′, Long. 119° 07.1′, 380 feet. Collections from trawls show that decapod, euphausid, and mysid shrimps are fairly abundant. Some small deep-sea fish have been recovered in the trawls but are not apparent in the photographs. Animal in upper center is unidentified. November 18, 1951, 8:30 A. M. (AHF 2083.)

known to migrate vertically through the water, tending to stay in light of the same intensity. Some of them rise so near the surface at night that many are caught in ship intake strainers. Most of these animals are shorter than 2 inches and, because physicists believe that the bodies that cause the echo must be about 6 inches long, it has been suggested that the echos are from squids and fish that feed upon the crustaceans and move vertically through the water as their food supply moves.

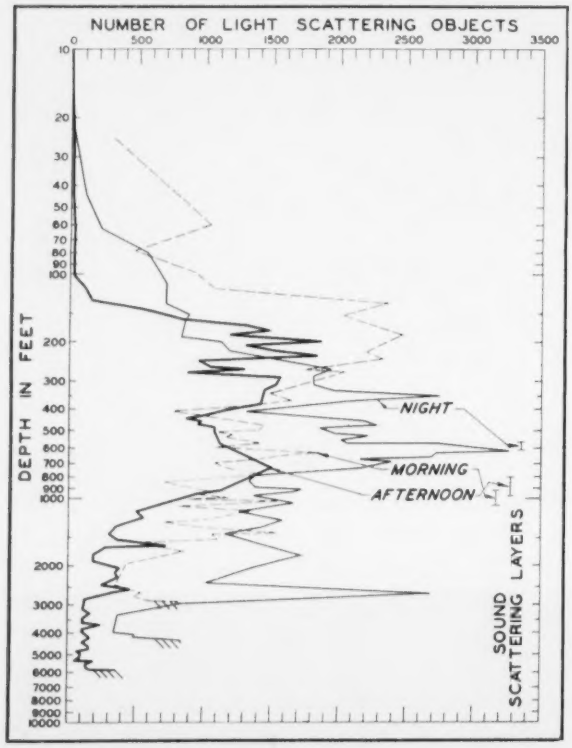


FIG. 8. Graph showing vertical distribution of light-scattering objects as counted from photographic negatives. Concentrations indicated as more than 2000 are probably even greater than shown because "soupy" texture makes counts difficult. Night series above Catalina Basin, Lat. 33° 24.2′, Long. 118° 50.9′. March 30, 1952, 3:30 A. M. to 5:00 A. M. (AHF 2099.) Morning series above San Nicolas Basin, Lat. 33° 04.5′, Long. 119° 07.1′. November 18, 1951, 8:30 A. M. to 9:30 A. M. (AHF 2083.) Afternoon series above San Pedro Basin, Lat. 33° 35.4′, Long. 118° 28.2′. March 29, 1952, 1:00 P. M. to 2:00 P. M. (AHF 2096.) The top of the sound-scattering layer was at a depth of 560 feet at night, 920 in the morning, and 800 feet in the afternoon series.

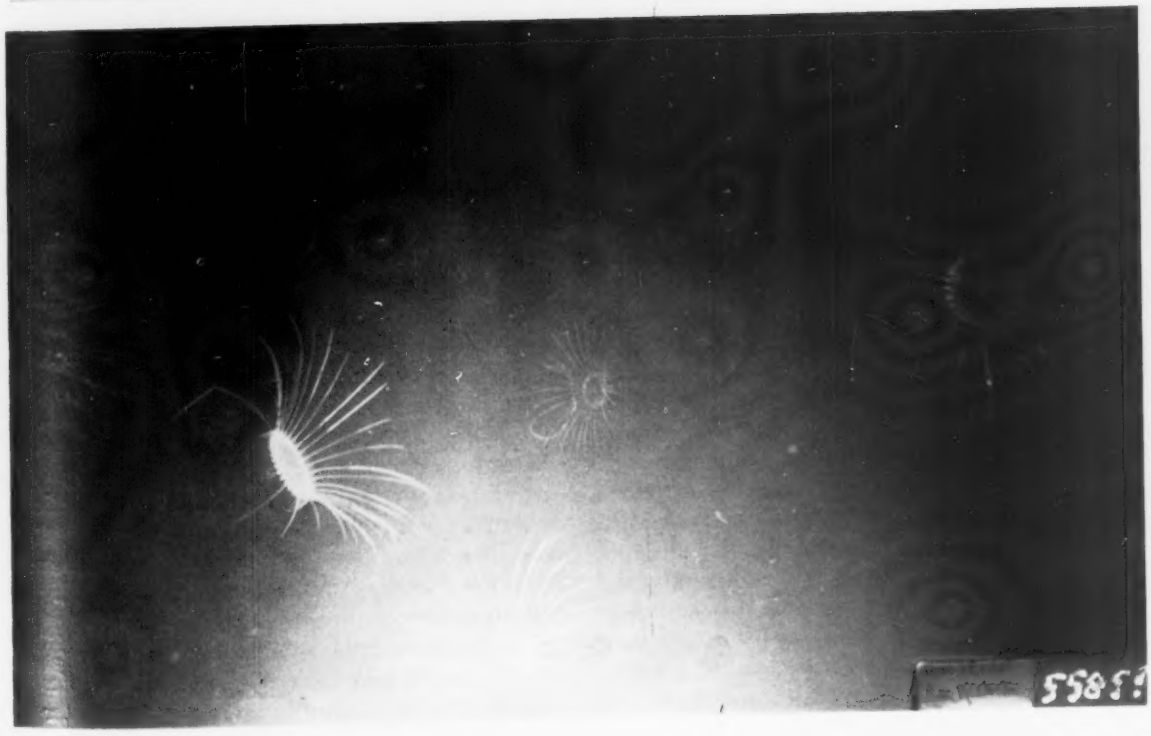
Extensive trawling in the sound-scattering layer has recovered large quantities of decapod, euphausid, and mysid shrimps, but only a few squid and fish. Since the fish and squid may be able to swim out of the trawls, some other method must be used to determine their distribution. The benthograph appears to be the best tool for that purpose yet devised, especially when combined with data from trawls. Some preliminary results are presented in Figures 7 and 8. The photographs show a concentration of light-scattering objects, mostly too small for identification, and ranging from sharply defined points, vague blobs, clusters and strings of dots, to elongate streaks. Others are probably identifiable organisms. Perversely, however, the zones showing the most light-scattering objects do not correspond with the zones of sound-scattering objects, being shallower and, in results to date, being deeper at night than in the daytime. No peculiarity at the depth of the "false bottom" has been detected on the photographs.

FIG. 9. Water 10 feet above bottom of San Pedro Basin, Lat. 33° 35.4′, Long. 118° 28.2′, 2916 feet. Siphonopores (elongate objects) and medusae (umbrellas near top of photograph) are common. Siphonopore in middle estimated to be 3 feet long. March 30, 1952. (AHF 2096.)

Photographs also show an unexpected concentration of large coelenterates near the bottom, particularly in the more stagnant basins. Long thin siphonopores (Fig. 9) and medusae, or jellyfish, are common. The medusae include simple opaque umbrellas and beautiful translucent forms (Fig. 10). In a single lowering, 60 of the latter were counted, all but two of which were between 5500 feet and the bottom at 5840 feet. Because of their nearness to the bottom, none of these coelenterates is known to have been recovered in trawling operations in this region. Their depth distribution is probably related to the profusion of organic matter in the sediments of the basin floors.

The results discussed here by no means exhaust the list of problems that can effectively be studied with the benthograph used as a camera. For example, the benthograph might be left for several hours in shallow water where there are many fish until the fish become accustomed to it. Photographs could then be made, showing much of the natural activity of the area. It should be a useful tool also for investigating turbidity currents. Left at the base of a slope, it could record the appearance of a turbid cloud of water carrying sediment stirred up by a ship dragging a dredge across the upper part of the slope. These and many other problems will eventually be investigated.

FIG. 10. Medusae (possibly of genus *Atolla*) in water near floor of San Nicolas Basin, Lat. 33° 04.5′, Long. 119° 07.1′, 5585 feet. Photographs from two separate lowerings of the benthograph showed these organisms chiefly between a depth of 5500 feet and the bottom at 5840 feet. Bottom edge is about 6 feet wide. November 18, 1951. (AHF 2083.)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The Unlisted Freedom: Science

CARL E. TAEUSCH

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THE four freedoms of the First Amendment to the U. S. Constitution have been fairly well established and defined: the freedoms of religion, of speech and of press, and of assembly. But two other freedoms are nowhere recognized in the Constitution: the freedom of science and of art. These, like the four mentioned, may have been so much taken for granted by the framers of the original Constitution that they deemed it unnecessary to list them specifically, even when the other freedoms, those of Amendment I, were explicitly recognized in response to the demands of the ratifying states. But recent events have made the issue a live one, especially as regards science. And we may yet need to formulate another constitutional freedom.

As matters now stand, we are using constitutional concepts that were formulated before science reached its present complicated and significant status, to solve problems that were not anticipated by those who wrote the Constitution and added to it the Bill of Rights. The method of "adaptation" of older concepts to newer situations has been used also in cases involving freedom of speech, where technological developments introduced the movie and the loud-speaker, the dictaphone and the detectograph, making broadly public what previously was confined to small areas and to relatively few people. The manipulation of the older legal concepts, so as to make them function in ways in which they were never intended to be used, has at times been nothing short of brilliant; as, for example, when the responsibility for the damages of a balloon—as among the business sponsor, the flight engineer, the occupants, and the "helpful" villagers who pulled it down before the explosion—was made the basis for determining the liability of remarks made during a radio broadcast. But this has not always been a sound method by which to control the modern social implications generated by recent scientific innovations.

Scientific Freedom

The recent controversy revolving around the Lysenko case is already well known to readers of THE SCIENTIFIC MONTHLY, SCIENCE, and similar scientific publications. And scientists generally are acquainted with the vicious challenge of the Hitler doctrine of "racism," as well as with the confusion of political policies with scientific method which the Russian "environmentalists" have introduced. The censoring of textbooks, the rationalization of social snobbery or egalitarianism, and the more general government controls of scientific institutions and organizations resulting therefrom, have reversed the development of scientific freedom which the Western world has taken centuries to achieve. But even the forthright letter of H. J. Muller, resigning his membership in the Academy of Sciences of the USSR, failed to keep completely clear of the basic difficulty. Instead of confining the issue to that of the fundamental freedom of scientific inquiry, he concluded his letter with a defense of the geneticists' stressing of the hereditary factors, and thereby switched the controversy to the relative merits of the substantive matters in question. Instead of arraying the free discovery and establishment of supporting facts against the arbitrary political choice of a political doctrine, the scientist needs to insist on the "separation" of science and government so as to let the theoretical, analytical, and experimental chips fall where they may. For it is on such a basis that the other freedoms have been established as fundamental if not absolute rights.

The political implications of scientific freedom are no longer easy to avoid anywhere. Professor Muller emphasized the international character of

science and the view that it knows no international boundaries. But when internationalism itself becomes a political issue, as it has today, the attempt to maintain that character of natural science as an absolute becomes involved in political issues. For well-meaning scientists may be duped by crafty propaganda into attending an "international scientific meeting" which may have been instigated by Communists for partisan purposes. The problem also arises in connection with the general publication and distribution of the results of scientific inquiry. For such a procedure may disclose matters that are essential to national defense; and the U. S. Supreme Court has not hesitated to regard this latter "value" as equally fundamental with that of our individual rights or scientific freedom. It will not do to insist that attendance at such meetings, or that such publications, are implied in the fundamental postulate of scientific freedom, and that they contribute a necessary check to the sound development of science itself. Like the other freedoms, that of science may be fundamental, but it is not necessarily absolute. And it is the very function of the courts to reconcile such freedoms with the equally fundamental consideration of the public welfare.

The situation has been aggravated by the hiatus that has been allowed to develop between the technical training of scientists and their social education. There result such anomalies as the inability of the technically trained engineer to make himself understood in the English language, so as properly to promote a justifiable program of public works; the narrow and misguided policies of some national organizations; or the uninformed pronouncements of physical scientists on economic problems. One might include, in an extreme category, the dangerous lack of good sense and of sound judgment of a Gold or a Fuchs. That this gap between scientific-technological training and social values must be bridged has long been recognized by scientists themselves. And the difficulty can also be attributed to public officials, ignorant of science, whose amateur attempts at interference and control are endangering sound science. Any attempt to phrase an amendment to the Constitution or to enact satisfactory federal or state legislation should engage the best cooperative efforts of at least these two groups of people.

The democratic solution of the problem would require that we rely heavily on the good sense and sound judgment of the scientific organizations themselves. But here the problem of effective sanctions is yet to be solved. Matters of public danger and of national defense can no more be left solely to the scientists than can public or international policies be left only to the generals. In the meantime, many of the political controls now being exercised over scientific activities are jeopardizing the very foundations of science. Are the scientists socially equipped to handle this problem? Even the scientists themselves are not keeping uppermost the principle of free scientific inquiry, let alone recognizing the essential relationship of pure, experimental, and applied science to the national welfare and defense.

Atomic Energy and "Loyalty"

As with all other freedoms, the exercise of scientific freedom may run afoul of other basic social postulates. Freedom of conscience itself may have to be curtailed in certain circumstances by the demands for national security. And the advent of the atomic bomb has presented a new angle of this problem forcefully to our attention. Do the political or economic views of a scientist, who has admittedly superior technical ability, form a sufficient basis for excluding him from participating in nuclear research or adaptations of it to the problem of atomic fission? Even the Nazis utilized the indispensable knowledge of Jews like Messerschmidt in developing their aircraft program. Should an unfavorable social belief ban a superior scientist from partaking of "secret" or "restricted" or "confidential" information? The problem is not merely abstract or general. Any solution of it must anticipate the possibility that the test of the scientist's "loyalty" may, practically, be conducted and even determined by a relatively unimportant administrator, or by a relatively ignorant and irresponsible lawyer delegated to perform the duties of an official legislative investigating committee, many of the members of which do not appear personally.

When E. U. Condon was appointed director of the National Bureau of Standards, his selection received general approval from scientists. In his inaugural address, he stressed the universal character of science and warned his listeners and readers that he would not tolerate interference with the scientific inquiries for which the bureau had established a worldwide reputation. But some Congressmen never forgave him for this characteristically honest and forthright statement. He was subjected to severe criticism, charges of "disloyalty," and investigations that interfered with the work of the bureau and undermined its morale. His attendance at international scientific meetings was interpreted as "association" with Communists, and his insist-

ence on the dissemination of knowledge concerning scientific discoveries was regarded as "giving assistance to the enemy." This is not an environment in which science can best function, and he finally resigned his post. His scientific soundness was attested to by his appointment as director of the research laboratory of one of our outstanding industrial companies and by his subsequent election as president of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Can the government afford to lose the services of such an outstanding scientist?

In August 1949, the Congress of the United States passed an act requiring all holders of Atomic Energy Commission fellowships to be given "clearance" by the commission after having been investigated as to character, associations, and loyalty by the Federal Bureau of Investigation. The bill was obviously intended to apply to the "classified" or confidential activities of the AEC. But it was equally clear from the hearings that the act would also affect those scientists who were dealing with nonsecret or nonofficial problems in the more basic sciences, for which there was no point in determining their social, political, or economic views. To an amateur, this distinction may not seem important. But that it was, is disclosed by the exchange of correspondence, familiar to AAAS members, between the AEC and the National Academy of Sciences. In September 1949, the general manager of the AEC wrote the president of the National Academy suggesting cooperation with this nongovernmental body and the quasi-official National Research Council and welcoming recommendations. The upshot of this correspondence was a declination by the academy to accept the proposal. The clearance program was held by the latter to have been "ill-advised," especially for work of a nonsecret character, the value of the broad program was held to be "greatly reduced" by such "restrictions," and "grave doubts" were expressed as to whether the continuance of the fellowship program "thus restricted" was in the national interest.

The statement of the academy concluded with an assertion characteristic of the sanctions of a "free association;" namely, the refusal to accept public responsibilities incompatible with the private nature of the association. It offered to act in an advisory capacity, and it suggested that the AEC "take all proper steps to see that these restrictive provisions be omitted from future legislation." And the academy announced its intention to present directly to the government the reasons for its views. The statement included an Annex, suggesting practical compromises and a *modus operandi* for the interim period until the AEC could take over the obligation entirely. It contained three pertinent statements: that the AEC itself operate the program; that prospective fellows be fully informed of the conditions affecting the program; and that the "misgivings" of the academy "about F.B.I. investigation and AEC clearance do not apply to candidates for secret work." A working program for the council of the academy and the commission was agreed upon. But the academy insisted that the functions to be deferred to responsible public officials were not pertinent to a free scientific association, and that the pursuit of free scientific inquiry could not be hampered by governmental or political considerations.

The consideration of the blighting effect of outside controls, in deterring scientists from entering the field, handicapping them in their work, or causing them to leave for more congenial occupations, suggests broad analogies. In economics, there is the "flight" from the pound or dollar; Gresham's law, by which "bad money drives out good;" the "buyers' strike" against high prices or shoddy goods; or the "run" on an allegedly unsound bank. There are the blighting effects of censorship on art or literature; as John Milton observed, they may not merely kill a book, they stultify creative work. Free scientific inquiry involves tough-mindedness, but even this sometimes wilts under outside interference. And where interference extends to matters beyond the need of safeguards, the results may be disastrous to basic science and thereby to the welfare and safety of the nation itself. Private scientific organizations exercise their prime function when they protect their members against unwarranted governmental or private restrictions, especially in a democracy.

Even though there may be no sound objection to the laws or general regulations governing such matters, administrative incompetence or overzealousness or even tyranny may present the danger in no less important degree than does unwise legislation. Thus the administrative difficulties of the Loyalty Order of the President of the United States were anticipated by a letter, signed by four members of the Harvard Law School and published in the New York *Times* on April 13, 1947. It was "possible," said the signers, so to administer the order as to accomplish its ends. But it was "also possible" so to administer it as to "victimize innocent persons, discourage entry into the public service, miss genuine culprits, and leave both the

Government and the American people with a hangover sense of futility and indignity." Like all other statutes, rules, and regulations, "the nature of its administration will hinge upon the procedures to be followed." Star chamber methods are possible, especially where the investigators are given blanket discretionary powers; or where the accused might or might not be confronted by the charges, the evidence, or the witnesses, so that he would have no adequate or accurate means of rebutting such as are unfounded. No recording of the hearings, if there were any, was provided, giving little or no basis for the operations of the Loyalty Review Board. And now that the "impalpable standards" of the "reasonable grounds" for holding a person to be "disloyal" have given way to the reverse rule that the accused prove his loyalty "beyond a reasonable doubt," we find ourselves relinquishing a centuries-old legal and social rule that a person be presumed innocent until he is proved guilty.

That the situation was not merely academic, even before the new procedural ruling, was shown by the report of the Committee on Secrecy and Clearance of the Federation of American Scientists, published in SCIENCE, April 2, 1948 (**107**, 333). Charges were found to have been based on mistaken identity and personal dislikes; and they extended to workers only remotely connected with "secret" or "confidential" experiments and employed in private industrial and university laboratories, leading to dismissal and subsequent unemployability even in private work. The dangerous and ludicrous stage to which we have fallen is illustrated by the (significantly anonymous) article, "Cleared for Top Secret," recently published in this journal (**74**, 145 [1952]). Scientists do not object to procedures safeguarding the nation. They do object to cures that are worse than the evil. And among the consequences they deplore is the fact that some of the official departments and agencies in which fraud and dishonesty have been disclosed not only had scrupulously observed the "loyalty" regulations but had also resorted to these very "secrecy" devices to conceal their malpractices.

The indiscriminate extension to all scientists of "clearance refusals" that should be primarily applied only to those engaged in "secret" work is but an extreme example of the series of slips that occur between the legislative cup and the administrative lip. And those few scientists who bestir themselves so as to keep informed of legislative enactments seldom continue their scrutiny into the field in which these laws are practically administered. Involved in such potential tyranny are arbitrary decisions, secret procedure, indiscriminate admission of evidence and the misinterpretation of it, unfair application, and sheer stupidity; all probably without keeping of proper records for review or the opportunity of appeal. The only apparent justification for such methods is that "Mother knows best," a supercilious attitude that has no place among adults in a democracy. Surely this presents a field day for "fantastic blunders under the influence of hysteric panic, legitimate fear, political pressures, and the venal exploitation of our danger by unscrupulous politicians."

We Americans are too prone to regard blunderbuss legislation as a means of casting our shortcomings on such Gadarene swine as "should get out of the way" or drown themselves. We, and scientists in particular, lack the realism that would give at least a similar amount of attention to care in administrative procedure. If half the amount of time and energy were spent by legislators in defining proper and adequate administrative procedure that is expended on minute and dangerous details of some slipshod scissors-and-paste bills recently enacted, many of these difficulties would be avoided. But scientists, as American citizens, should also scrupulously observe such legislative and administrative activities, to see that our precious "ordered liberty under law" is observed. And a minimum of such requirements should include proper provisions that accused persons be given an adequate and fair hearing.

The "Social Sciences"

The problem of scientific freedom becomes highly complicated and especially significant when it is applied to the social "sciences." One basic difficulty is that this field of inquiry has by no means achieved the exactitude and objectivity of the natural sciences. Whatever advances may have been made by the statistical approach to social analyses, the experimental method is practically forbidden; and controversial public questions and opinions become involved, however "expert" the social scientists may be. Even the law, theoretically based on a strict set of postulates, and generally following the rules of deductive logic, becomes interlarded with legislative and judicial prejudices. Economics runs all the way from the emasculated laissez-faire plaything of the "classical" school, through the historical postulates of Marx and the psychological assumptions of the Austrian school, to the "institutional" vagueness of Commons, the

Keynesian controls, and the Pollyanna doctrines of the New Deal. Government, like medicine, remains more an art than a science. And, although sociology and anthropology have recently achieved a degree of objectivity by studying situations distant in geographic space and in the remote past, they continue to be colored by present social attitudes and philosophies to which they may lend support.

To what extent may the teacher of the alleged social sciences speak his mind freely? In the classroom? On his own subject? On any subject? Outside the classroom, as a private citizen? Should a professor of economics publish his views of taxation, his special field, in opposition to the state legislature, which is at the time determining the university budget? Should a professor of science or philosophy in a denominational college, smilingly, tongue-in-cheek, sign a statement that a whale literally swallowed Jonah? Shall a mathematician remain silent when a legislature "simplifies" the value of π? Shall a teacher of social science remain silent when the mathematics or natural science instructors make statements ranging over any part of the whole field of religion, Communism, public utility rates, government welfare programs, the New or Fair or Square Deal, and the United Nations? What if these reactionary statements (as they often are) reflect the opinions of the board of education? The classical answer was made by A. Lawrence Lowell in his 1916–17 Report as President of Harvard College: that any attempt on the part of the university to interfere by censorship, dismissal, or otherwise would imply the endorsement by the university of all statements which its faculty were allowed to make—an obligation which no university could afford to assume.

The fairly recent request by a Congressional investigating committee (more accurately, by the chairman of the committee, without the knowledge of most of the members, as so often happens practically) for lists of books used in social science courses in colleges and universities was fortunately met by academic intestinal fortitude in pointing out the absurdity of the request and the impracticability of meeting it. In December 1947, the American Economic Association recorded its "continued affirmation" that teachers be free to select textbooks and implemented the proposition by setting up a committee of all past presidents of the association to supervise it. In December 1949, the American Philosophical Association asserted the right of teachers "to seek and teach the truth" and reaffirmed their right and professional duty to make independent evaluations, "no matter what the bearings of that philosophy on controversial issues of social policy." What is striking about these matters is not the character of the acts and statements, but rather that, in the USA today, they had to be made at all. The spirits of an older generation of college professors, of colonial ministers of the gospel, and of the statesmen who wrote the Constitution must not only have turned over in their graves: they probably are whirling like atomic vortices in the ethereal realm of freedom which we hope they still enjoy.

The situation in the University of California now seems on its way to a happy solution, but how long the scars will remain will be watched with concern. Not long before, when a state college withdrew a publication at the insistence of a farm association and issued a "revised" report, almost the entire economics staff resigned, and all subsequent publications issued by the college have remained suspect. As for the present rash of loyalty oaths, perhaps "this too will pass." Unfortunately, its more positive ill-effects are more noticeable than the plain fact that it does not achieve its objective. The oath means nothing to a Communist, who may lie about it and evade it by mental reservations. But there are people in this country who detest such hypocrisy, they are among the best of our citizens, and they believe in the political and social principles of freedom that have helped make this country great. They are the ones who can best be counted on to protect and defend the country in a real crisis, long after the witch-hunters mouthing their false and superficial patriotism have run to cover at the first sign of a change in the social or political atmosphere.

When one asks, what, then, can be the final check on the professional competence of an individual freely to "seek the truth" in its broadest and most fundamental sense, in the best spirit of scientific freedom, which at the same time recognizes equally fundamental social responsibilities—the answer is not, or is only partly, to be found in legislative enactments, "investigations," and even administrative procedures. Even more basically, the observance of recognized professional standards, as the Yale Alumni Committee declared, depends on "those restrictions imposed by conscience and morality . . . and the moral suasion of one's colleagues." This is the sanction which Chief Justice Stone asserted to be the final control of the court of last resort in this land. When a member of the Boston Symphony was asked how it felt to play before thousands of people, he remarked that the real criterion was the reaction of his fellow-

musicians. That such a court of last resort can at times fail is indicated by the recent attempt of the American Bar Association to set its own house in order, after admitting that the present wave of crimes and misdemeanors and malfeasances of public office has been aided and abetted by lawyers themselves. When scientists become provoked by inept legislation or unfair administration, interfering with the heart of their work, it may not be the "damned" Congress or some "damned" bureaucrat that is wholly to blame. It may be that the scientist himself failed to perform the responsibilities of citizenship which any democracy has a right to expect, especially in electing, and watching the behavior of, his representatives and officials, private as well as public.

The Problem Confronting the Scientist

What, specifically, can the scientist do about the matter? Let it be understood at the outset that he cannot himself or even through his organizations alone deal adequately with the problem. Not only have our "free associations" never discovered sufficiently effective sanctions, operating from within, to control that marginal group which is not affected by expulsion from membership or by professional disrepute. It has always been the function of the law to deal with such social recalcitrants. It must also be recognized that the fundamental freedom of science is bound to be confronted at times by equally fundamental but opposing social interests, and that the latter must be represented in the law and in government by officials who reflect a much wider constituency than scientists alone. Obedience to law, therefore, becomes a prime requisite which cannot be qualified by individuals or groups that hold the law to be unwarranted. Any such opposition must be confined to attempts to change the law by orderly processes, a method which requires concerted as well as individual efforts. Such attempts also require an informed public opinion among the members of the organization, which could well be extended to the general public by intelligent public relations activities. One of the best ways to change or eliminate a bad law is to obey and enforce it scrupulously.

In the case of the loyalty program more particularly, the scientist must bestir himself, first to fill in the lack of that social education which his exclusive and intensive scientific education has brought to pass. He must not only discover what government and the law are, but he must also understand why matters in such fields of human activity may be and may have to be different from the behavior in his own restricted field. Once having learned the ways of his fellow-men, he needs next to go about making those changes in law and government that will conserve the legitimate claims and rights and values of science to which its workers are entitled. But, above all, he needs to study the practical means by which he and his own scientific organizations, operating in separation from government, can effectively sanction those principles which free associations should assert as their prerogatives in our modern democratic society. For our democracy is as dependent, on the one hand, on the autonomous functioning of these associations as it is, on the other hand, on the will of the majority. And our democracy needs to be made to recognize these minority group rights, by their forceful personal support, as it has learned to safeguard the rights of the individual.

A study of recent loyalty legislation and executive orders will not disclose many positive or substantive defects, but most of them involve serious omissions of procedural safeguards. There is no disloyalty involved in insisting on provisions for a proper hearing during the execution of these laws and regulations, or in restoring to them the assumption that persons be presumed innocent until proved guilty. These are principles of Anglo-Saxon law that were achieved only after centuries of experience and struggle, they rest on the more fundamental natural law, and we have until recently assumed that the last three or four centuries of their observance had fixed them irrevocably into our social and democratic institutions. But apparently we must once again learn that "eternal vigilance is the price of liberty." Constant surveillance must guard against slovenly legislation, behind which administrative tyranny lurks. Writing his Congressman is a privilege which every citizen should exercise; he has a fundamental right to "petition his government for a redress of grievances," and Congressmen will welcome intelligent help in their difficult task.

As for court decisions, every American citizen may freely criticize those that have been made. It is only pending cases, while the courts are still hearing the issue or deliberating over the opinion, which require that comments be held in abeyance; otherwise a person may be held in contempt of court. What the citizen needs to watch scrupulously is the development of doctrines, in legislation, in investigating committees, and in the courts, which run counter to our fundamental social or legal principles, or which modify them seriously. Thus, the doctrine of "guilt by association" crept into

the Adler Case (1951), so as to come perilously close to violating the constitutional prohibition of "bills of attainder," as well as our fundamental legal rule that guilt is an individual matter and must be so proved. This development has not gone so far as Nazism and Communism, which extend punishment to other members of the family, but apparently a person may be held liable for the views held by his friends and associates! The only thing which prevented this view from being treated as legal doctrine was the fact that the case was largely a hypothetical one; no one was charged with the violation of the law, and the case should not have been heard by the court at all. Another implication of recent legislation and regulations, not yet become fully explicit, seems to point toward imposing guilt on behavior which occurred prior to the enactment of the laws or the issuing of the orders. This is clearly ex post facto legislation, which the Constitution explicitly prohibits. Has the social education of the scientist generally included such matters, which intimately involve his basic rights of citizenship, personal and professional, and his duty to safeguard them?

Let the scientist, therefore, take his nose off the laboratory grindstone long enough to examine the curriculum of his alma mater. There he may discover the imbalance resulting from an excessive emphasis on technical courses and a sad deficiency in social sciences and the humanities, and even in pertinent professional scientific matters in general. If a doctor discovered such deficiencies in a patient, or an engineer such stresses and strains, he would soon attempt to correct the difficulty.

Let the scientist also become a functionally operating member of his professional organizations; they need his help, and he may some day need theirs. In cooperation with them, let him peer as keenly into the functional operations of his government as he does into the equipment of his laboratory or the bodies and machines assigned to his care, and not rest satisfied merely with "having a law on the subject." Only by such an assumption of his civic responsibilities can he anticipate social developments; otherwise these may assume climactic proportions which suddenly face him and science in general with disastrously cataclysmic consequences.

HYDRAULIC JUMP

Avid white serpents,
Ice-white plumes distorted,
Hurl themselves, undaunted,
Up the river's current.
Gray-green weight of water
Ponderous, relentless,
Gathers speed and venom,
With each furious motion
Tangling in the struggle.
Hungry-mouthed, newborn of water,
Ice-white serpents endlessly
Engulf their source
And are, themselves,
Consumed.

ALICE G. ROULEAU

Oakland, California

The Unexplained Direction Sense of Vertebrates

WILLIAM J. BEECHER

The author has been associated with the Chicago Natural History Museum since 1936, in both the Division of Mammals and the Division of Birds. During the war, while serving with Army and Navy Malaria Control Units in the Pacific, he made numerous collections of vertebrates for the museum. Since the war he has concentrated on the functional anatomy of birds as a means of clarifying the relationships of bird families to each other. His article is part of a study of the vertebrate skull, particularly the ear region, on which he is engaged.

THE golden plover (*Pluvialis*) each fall flies a nonstop 2000 miles across the trackless Pacific from Alaska to Hawaii. The salmon (*Oncorhynchus*) returns from mid-ocean to spawn in the very stream in which it was born. A pet dog returns home over hundreds of miles of unfamiliar terrain. We are in danger of thinking of the "direction sense" here exhibited as commonplace because these events occur every day. But actually it is one of the unsolved mysteries.

Take birds, for example. If these mobile vertebrates were to survive as a type, the early models must have been able, despite stormy winds and extensive wandering in search of food, to return home to the care of young. Moreover, annual migrations may have been a necessity from the start. On a planet whose spin axis is inclined to the plane of rotation, there must always have been seasons, even sixty million years ago when Greenland was subtropical. These migrations probably became longer as the Tertiary unfolded and cooler climate crowded subtropical and tropical zones toward the equator, and the Ice Age saw birds pushed into our Gulf States and into Central and South America. Warm interglacial periods permitted long migrations, relieving the resulting population pressure, and finally the Ice Cap shriveled to the breeding relict we see in Greenland now. Today, waterfowl and other birds, following the long retreat of the ice, nest as far north as the short summer will permit successful raising of a brood.

What is the stimulus? We know now that it is not the warming weather but the increasing day length that conditions the northward migration of birds in spring and the growth of their reproductive organs.[1] Each species may "set its clock" by the day-length threshold that will time its arrival on the nesting ground as soon as it is ready for occupancy—a vital matter for short-season nesters beyond the Arctic Circle. And it is not simply the cooling weather that sends birds south in the fall, for some leave us in July and August. This was necessary in the Ice Age, and the day-length threshold triggering southward movement then may be still in effect, since natural selection imposes no penalty for early migration south so long as a brood is raised. Wolfson covers the physiological basis of bird migration admirably.[2]

What concerns us is the precision of these migrations. Many of these birds will return thousands of miles, flying through dark nights when they cannot see, to the particular thicket or meadow in which they nested last year. Moreover, the young in some species precede their parents in the southward migration to the wintering grounds, a journey they have never made before! This seems to imply inheritance of an instinctive direction sense, and such navigational ability may fall into the same class with the homing of pigeons or of swallows, used in war by the ancient Romans.[3] All that has been said of birds goes for bats and many other mammals (particularly aquatic ones), various fishes, and in lesser degree reptiles and amphibians.

Historically, the semicircular canals seem to be the first sense organs credited with space-orientation, de Cyon suggesting them simply because the three, fluid-filled, sensory canals on each side of the head lie mutually perpendicular in the three dimensions of space.[4] By 1882 Viguier had proposed that birds might be able to detect the earth's

magnetic field in the canals,[5] and by 1894 Hodge was claiming that pigeons home by random search.[6] All these viewpoints have been pursued intermittently down to the present without resolving the question. This is particularly interesting because each of these theories has been revived by modern workers employing relatively refined investigation techniques within the past few years. Their evidence and conclusions are reviewed below.

Griffin's Theory of Random Search

Griffin[7] believes that homing can be accounted for on the assumption that birds make a random search upon release until they chance to sight terrain familiar to them. Griffin and Hock[8] removed gannets from their nests on Bonaventure Island in the Gulf of St. Lawrence and released them 218 miles away at Caribou, Maine—70 miles from any coast. When followed by airplane these birds appeared to wander randomly until the St. Lawrence River or the coast was sighted, after which most returned home. The homing sense in these seabirds might not be expected to be highly perfected, since they are virtually never out of touch with coasts, and it is difficult to accept the application of these conclusions to all birds. Airplane observations of homing pigeons by Hitchcock suggest that a clear course toward the loft is taken.[9] It is hard to account for most homing by chance. Watson and Lashley reported noddy terns (*Anous*) returning to their nests on Bird Key, Florida, from Galveston, Texas (north of their range), a distance of 460 miles across the Gulf against heavy winds in three days.[10] Lack and Lockley report the record for wild bird homing in a Manx shearwater (*Puffinus*), transported from the coast of Scotland outside its range to Venice, Italy.[11] It returned the 3700 miles in fourteen days, *averaging 260 miles per day!* When it is remembered that in both cases the birds would have to rest at night and feed on the way, even a thirteen-hour flying day seems excessive, yet this gives an average speed for the shearwater of 20 miles per hour.

Yeagley's Theory of Homing by a Coriolis-Magnetic Grid

Yeagley hit upon the ingenious idea that pigeons may home by detecting the effect, due to their movement through the air, of the earth's magnetic field and of the Coriolis force caused by the earth's rotation.[12] Lines representing equal intensity of these forces form a gridwork, those of Coriolis force being true latitude lines, those of magnetic force dipping down so as to intersect the latter at two points in North America. The essential fact is that the intersection at Pennsylvania State College is duplicated by a conjugate point at Kearney, Nebraska (Fig. 1). Yeagley trained pigeons to home up to 70 miles to a mobile loft at State College, then transported them, with the lofts, to the vicinity of Kearney. He theorized that, if pigeons correlate their ground speed with these two forces to return to the loft where they effect the right "feeling," then the birds should experience the same feeling at Kearney and should return there if released in its vicinity. Three groups of birds were released—one near Kearney, one near State College, and one midway between.

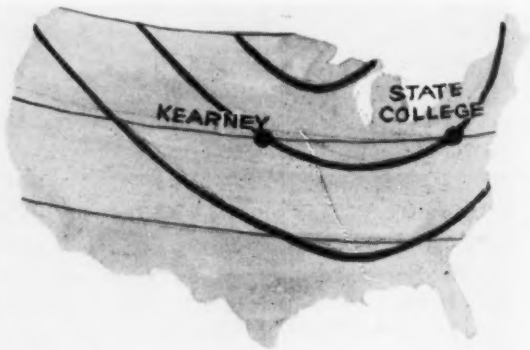

FIG. 1. Map of the United States showing Yeagley's Coriolis-magnetic grid.

Although the last group were in a "tangential" area of parallel grid lines, where navigation should be impossible by Yeagley's theory, homing was easterly. This agrees better with a simple Coriolis theory than with magnetic field or grid detection. In fact, Thorpe[13] suggests that there seemed to be a tendency to home to the correct latitude. Yeagley believes the total flight vectors in these three groups support his theory, but this does not appear to be the consensus. The superimposing of a pulsating field (to destroy the effect of the earth's magnetic field) was effected by attaching magnets to the wings of pigeons, but this apparently did not affect their performance when compared with controls. Other experiments of this sort have always been negative. This valuable work is hard to assess because of terrain and meteorological differences between Pennsylvania's mountains and Nebraska's prairies. There is also a suspicion that homing ability has been "domesticated out" in pigeons. Although Yeagley is continuing his experiments with wild ducks, these are mainly diurnal and may migrate by visual clues. One would like to see the many nocturnal migrants tested for homing ability, as was done with swallows (*Hirundo*) by Polish investigators.[14]

Ising's Theory of Coriolis Force Detection in the Semicircular Canals

Ising thinks birds find their way by detecting the Coriolis force due to the earth's rotation.[15] Any object on the equator has a momentum of about 1000 miles per hour (the earth's velocity at the equator), whereas objects at the North Pole have a momentum of zero. An object projected through the air at the North Pole from the equator will curve to the right because it is progressively moving into latitudes of lesser momentum. The force it would have to overcome to fly to the pole is Coriolis force. Ising showed that a microscopic streaming occurs in a fluid-filled glass tube fashioned into a ring (Fig. 2) when it is rotated on its own diameter. This hydromotor force, which is due to Coriolis effect, obeys the same law as induced emf in a closed conductor, and Ising suggests that the direction sense of birds may be based on the motion, relative to the rest of the bird's body, of the fluid in the semicircular canals. The three canals of the inner ear are mutually perpendicular (Fig. 3) and thus are oriented in the three dimensions of space on either side of the head. Within the bony canals are membranous canals filled with endolymph, each one terminating in an ampulla containing a crista in which sensory hairs enveloped by a gelatin cupula or door record flow of endolymph. This is an inertia system, and the normal function of the canals is based on the inertia of this fluid. When an animal swings its head, the endolymph of the canal in the plane of the movement remains behind. Relative to the cupula it flows in the opposite direction, its velocity and amplitude directly proportional to the head movement. Ising reasoned that in such a system there should be an inertia effect resulting from the attempt to fly a true course despite the deviating influence of Coriolis force. His critics[16, 17] object that the effect is too small for the sensory apparatus to detect (about the amplitude of Brownian energy), but if the bird turns its head from side to side more rapidly, especially in flight, the force would increase considerably.

It has appeared to me that the semicircular canals may be more than a latitude sense, measuring the increasing value of Coriolis force northward.[18] They should serve as a "gyrocompass," since Ising measured different values for different compass directions of the couple on the glass ring. But it also follows from Lowenstein and Sand's[19] finding that the ampulla in the living semicircular canal discharges spontaneously and that any rotation of the animal producing flow in a canal toward its ampulla enhances the discharge, whereas flow away from it inhibits the discharge. Thus, if we visualize Coriolis force acting from west to east on the latitude lines (Fig. 4) there should be a streaming in the four vertical canals for a northward course which is inhibiting (−) in the ampullae on the left side, enhancing (+) in the canals of the right side. On a northwest course all the streaming will take place in a single canal of each side, since the other vertical canal will be at right angles to a force acting from the west. Although it must not be imagined that Coriolis force acts so simply, there seems to be a basis for thinking that the opposing sign of the canals of the two sides affords a means by which the resolution of the force for any latitude among the six ampullae will be different for each compass direction.

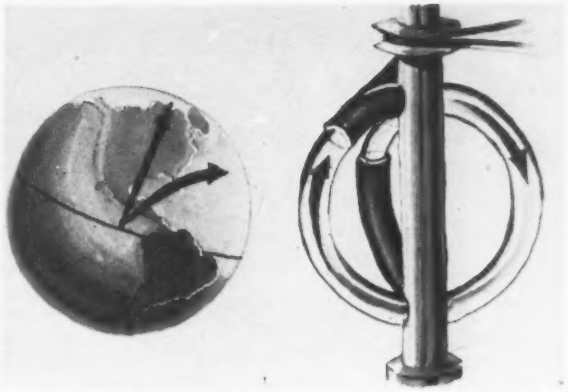

FIG. 2. Left, diagram showing the tendency of an object projected at the North Pole to curve right because of Coriolis force. Right, reconstruction of Ising's ring for measuring the force.

The maculae of the utricle, saccule, and lagena of the inner ear (Fig. 3)—each a layer of calcium carbonate crystals (30 μ) embedded in gelatin on a mat of sensory hairs—form a gravity system similarly opposite in sign for the two sides. This may also aid direction-finding in the canals by measuring the deviation from the pull of gravity resulting from Coriolis force. In their normal functions the roles of the canals and maculae are supplementary, even complementary, the latter reporting deviations of the head from the horizontal by the effect of slight weight shifts of the crystals on the sensory hairs.

If this analysis is correct in principle, the canals and maculae may balance the Coriolis force value of a particular latitude differently for each direction—with the qualification that directions 180° different will produce the same sensation. This provides a theoretical basis for the inheritance of a direction sense that would permit young birds to migrate south before their parents and for local

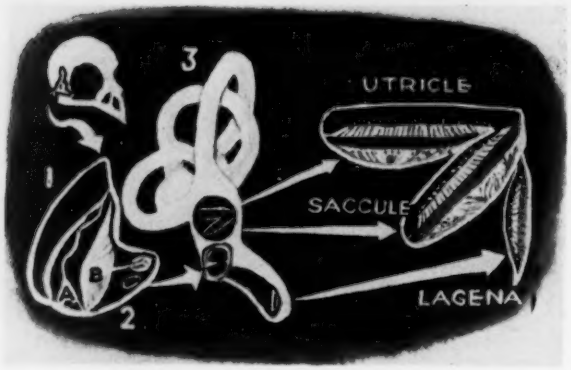

FIG. 3. The avian ear: (1) outer, (2) middle, and (3) inner ear; (*A*) cavernosa, (*B*) drum.

populations of a species to pass on genetically the *exact* direction taken to breeding and resting grounds. The force, of course, increases on a northward course, decreases on a southward one. Thus young European storks (*Ciconia*) precede the parents to the wintering grounds in South Africa. West German storks migrate southwest through France and Spain to Africa by way of Gibraltar; East German storks of the same species migrate southeast through Transylvania, the Balkan Peninsula, and Asia Minor to Africa by way of the Nile Delta. Eggs of East German birds raised in West Germany hatch young that migrate by the route normal to East German birds in an environment where adult birds migrate in the opposite direction—indicating an inherited direction sense.[20]

Other Phenomena Supporting the Coriolis Force Theory

The larvae of European and American eels (*Anguilla*) afford a striking case of inherited direction sense.[21] In the breeding ranges of the two species south of Bermuda, the larvae hatch and are found together but separate as they migrate in opposite directions. Larvae of the American eel swim *west,* metamorphosing into elvers in *one year,* at which time they find themselves off the eastern coast of North America, up whose rivers they swarm to complete their growth. Larvae of the European eel swim *east,* metamorphosing in *three years,* at the end of which time they have reached the coasts of western Europe, in whose streams they complete their development. The well-known ability of the Pacific salmon to return from far out at sea to spawn in the stream in which it was born,[22] of the fur seal (*Callorhinus*) to make a long migration on a true course,[23] and of the green sea turtle (*Chelonia*) to home indicates that direction sense is most highly evolved in animals living in the fluid media of the earth. It is on these fluid media that Coriolis force acts (trade winds and ocean currents), and it may also affect the fluid in the canals possessed by all these animals in common, even though the fish lack the outer and middle ear. Homing always implies return to a known locale and is known in all vertebrate classes—e.g., in frogs,[24] toads,[25] box turtles,[26] snakes,[27] mice,[28] and flying squirrels.[29]

Direction-finding possibly related to homing and migration is ability to run a maze. Watson[30] found that maze-learning was not impaired in white rats by experimental extirpation of eyes, middle ear, olfactory lobe, or vibrissae, or by anesthesia of feet and nose, or even by elimination of air and temperature currents. But he obtained one result with these animals that he was unable to explain satisfactorily. When the maze was rotated 180° the animals were still able to run it, with some initial hesitation, but when it was rotated 90° none of them could run it. One hardly dares suggest that these animals could run the maze by detecting Coriolis force in the canals and maculae, yet the inner ear alone remained, excepting possible kinesthetic receptors in muscles and joints. In the case of the latter, rotating the maze should have no

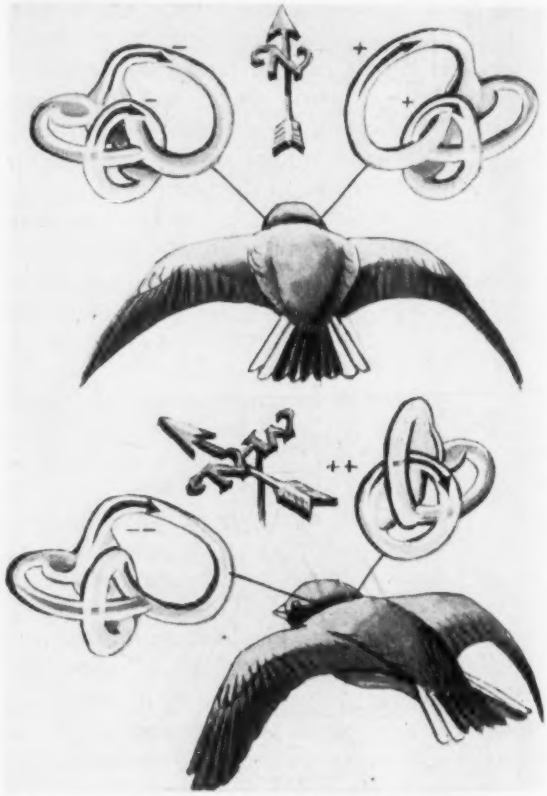

FIG. 4. Position of semicircular canals (enlarged) for flight on different compass headings, with theoretical resolution of Coriolis force streaming.

effect, but if the rats were oriented by Coriolis force, rotation 90° might have the effect noted. It seems possible that, with other senses removed, the inner ear could become supersensitive to Coriolis force.

Other vertebrates learn mazes readily, turtles showing as much aptitude as laboratory rats.[31] Birds are slower than rats, but the cowbird (*Molothrus*) and English sparrow (*Passer*) learn faster than pigeons (*Columba*).[32] Birds seem to react to most environmental stimuli with complex but stereotyped instinctive responses, and concentration on learning is difficult (they are "bird-brained," in other words). English sparrows were confused when the maze was reversed, persistently trying to make certain turns as they had been accustomed to do, suggesting a sense of absolute direction.

Bats (*Myotis*) seem to have such a sense. When conditioned to fly to one end of a cage 27 inches long for food, they continued to fly to the same absolute spot in space after the cage had been rotated 180°, even though the white square of cloth on which they had been conditioned was plainly visible at the original end of the cage.[33]

Some Peculiarities in the Ears of Birds, Bats, and Aquatic Mammals

I have found that birds that migrate mainly at night, feeding and resting by day (especially songbirds), have a membranous sac (Fig. 3, *A*) lining the bony wall of the outer ear.[18] This sac is composed of cavernous tissue which can be inflated with venous blood by the action of *M. tensor tympani* in damming the auricular vein leading from it. It seems to be a mechanism for covering the drum (*B*), which in small birds is ten times the relative size in man. Since the outer ear in such birds is shaped a little like an air scoop, and its opening is thinly veiled by auricular feathers designed to admit air, the head-turning postulated by Ising would, at 40 miles per hour, set up strong plus-minus pressures on the drum. These would make it difficult for the bird to make an estimate of Coriolis force, and it may be under these conditions that the sac is inflated. It is interesting that this tissue is specialized as a cavernosa just in those species making the most phenomenal, chiefly nocturnal, migrations—warblers, buntings, thrushes, golden plover, etc. The diurnal ducks, geese, and swans, generally thought to migrate by visual clues, lack this specialization. In them the sac is composed of relatively undifferentiated connective tissue, but in the ruddy duck (*Erismatura*), which alone migrates habitually at night,[34] the sac contains a venous plexus approaching the cavernosa.

Cavernous tissue has also been reported in association with the drum of bats,[35] though it may never amount to more than a venous plexus.[36] Eschweiler thought the filling of this cavernosa with blood might create tension on the drum in place of the missing *M. tensor tympani* in the pangolin (*Manis*).[37] This tissue has been reported also in the armadillo (*Tolypeutes*) and hedgehog (*Erinaceus*), but in my own dissections of the ear in bats I have not been much impressed with it, nor is the mechanism by which it might be induced to swell evident. However, the cartilage at the base of the pinna seemingly forms a series of valves (Fig. 5) which may close under the combined effect of

FIG. 5. The pinna of a bat's ear (*Lasiurus borealis*).

the venous plexus and the extrinsic ear musculature. Griffin and Galambos[38–41] have shown that plugging the ear in bats prevents their hearing their own supersonic cries, but they might momentarily close their ears in homing or migrating, as was suggested for birds. Curiously, neither bats nor birds close the ear in response to foreign objects threatening the drum and thus may only do this in flight when trying to determine direction in the inner ear.

In all these animals having a cavernosa in the ear or an approach to one, a common need to close the external ear exists. The pangolin, armadillo, and hedgehog are burrowing animals, and the need for closing the external ear opening in bats and birds has already been suggested. Aquatic mammals are apparently also able to close the ear.[42] And now a curious relationship is seen: vertebrates living in the earth's fluid media—air and water—can either close the outer ear or (like turtles and fishes) have it lacking. It may be coincidence, but these are the animals that exhibit homing and migration most dramatically, and in them the inner

ear, suspected of detecting direction stimuli, is peculiarly protected from disturbing effects of the medium in which they live. The olfactory sense may aid salmon in homing to a stream[43] but hardly accounts for its long sea journey—and this sense seems to be totally lacking in birds.

Other Theories of Bird Orientation

Rüppell[44] showed that hooded crows (*Corvus*), carried west of their regular migration route in Europe, migrate on a course parallel to it, and Hitchcock found that pigeons trained to fly in only one direction to the loft will, if released off this flight line, continue to fly in this direction.[9] Possibly these facts are explained by Matthews' observation that overcast skies have a disorienting effect on homing pigeons.[45] At any rate, Kramer has been able to modify the tendency of starlings (*Sturnus*) in an outdoor aviary to migrate in a particular direction by altering the normal incidence of light with mirrors.[46] Conditioned birds were also confused in their selection of feeders, concentrically arranged around a cage, by mirrored light. Although they do not perceive the polarization pattern of the sky, they apparently allow for the daily movement of the sun. Pigeons show the same ability, and Matthews thinks gulls home by sun navigation.[47] Unfortunately none of this explains how starlings and the great host of birds migrate at night. Such birds are waifs of the wind and with their poor nocturnal vision could hardly risk alighting at night.[48] Once launched on a migratory flight, they must presumably continue until dawn, and a direction sense must be assumed. The moon may be ruled out, for they often migrate on nights when it is not visible. The largest migration waves occur in the spring in the warm sector of a low pressure area, when the sky is overcast and even stars are invisible.[49]

It is vital that such waves wait on southerly winds—strong Gulf air masses apt to hold all night. On a west wind, coastal migrants would be carried east while flying north. Dawn would find them over the Atlantic, an error lacking in survival value. So it may be that these waves have evolved in adjustment to the peculiar spring barometric patterns of eastern North America.

Drost[50] believes flying birds respond to radar waves, and Kramer,[51] theorizing that they might detect the low-energy, ultra short-wave frequencies emitted by the sun and several stars, tried to obtain evidence. He failed to get reactions of any kind from red-backed shrikes (*Lanius*), flying or perching, to wavelengths of 60 cm, although the field intensities were similar to those used by Drost.

Examples of direction-finding from all vertebrate groups have been assembled here in an effort to discover a common denominator. The maze-learning results may not be examples of the same phenomenon, and for the other examples it is clear that present evidence does not permit generalizing from species to species. The homing ability of gannets does not seem to be of the same order as that of the Manx shearwater, and the sun-compass supposedly used by starlings in daylight could hardly serve them during their nocturnal migrations. Available evidence suggests that the direction sense is most highly perfected in animals of the fluid media—air and water—animals in which the outer ear is either lacking or may be closed against pressures incidental to movement through the media. A certain amount of circumstantial evidence thus supports the theory that the inner ear may detect Coriolis force and employ it as a compass.

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Trace Elements in Geochemistry and Biogeochemistry

HARRY V. WARREN and ROBERT E. DELAVAULT

The senior author, born in Anacortes, Washington, took his B.A. at the nearby University of British Columbia and has been in the Department of Geology and Geography there since 1932. During 1926–29 he was a Rhodes scholar and took his Oxford D. Phil. in 1929. He was a Commonwealth Fund fellow at Caltech from 1929 to 1932. Dr. Warren has done work on the lead and zinc deposits in southwestern Europe, on grunerite in the high Pyrenees, and on gold, silver, and strategic minerals in the Pacific Northwest. Dr. Delavault, born in Edmonton, was educated at the Sorbonne and at the Institute of Applied Chemistry, Paris. His scientific work, in the laboratories of mineral chemistry and mineralogy of the Sorbonne, and the laboratory of mineralogy of the National Museum, has been concerned mostly with applications of chemistry to metallurgy and mineralogy. He has been with the Department of Geology and Geography of the University of British Columbia since 1947.

IN THE distant past a scientist was expected to comprehend all sciences. Gradually specialization became the order of the day, and eventually it was the exception rather than the rule for a scientist to be well informed about those sciences with which he was not immediately concerned. Along the frontiers of the various sciences, however, there lie fruitful fields in which, by integration and cross-fertilization of knowledge, great productivity may be expected. Geochemistry and biogeochemistry afford good examples of sciences which through the integration of specialized knowledge may lead to discoveries and progress in other and possibly unexpected fields. Agriculturists, foresters, geologists, and medical men alike may find that by making use of the knowledge acquired in one another's fields of specialization and by employing at the same time the tools of physics, chemistry, biology, and botany they may advance their own branch of learning more rapidly than they thought likely, and perhaps along unforeseen paths.

Without having any positive intentions we ourselves have already become involved not only with those whose chief studies are in the fundamental sciences but also with those whose interests lie primarily in the fields which, for lack of a better term, we may call the applied sciences, such as forestry, mining, agriculture, and medicine. It is reasonable to expect that many of these fields will see advances and discoveries made by teams of workers rather than by individuals working alone. All are aware of the difficulties involved in achieving cooperation on international matters; similar difficulties, alas, beset those who attempt to persuade scientists to cooperate. Tangible rewards in the form of financial emoluments to workers in the marginal fields are meager: they have no lobby of informed opinion, either public or scientific, behind them. They are, however, offered intangible satisfactions, such as stimulating associations and the thrill of being involved in unusually interesting discoveries: their lives are not likely to be dull. It is doubtful that the intangibles will overweigh the tangibles and that an adequate supply of researchers will soon be forthcoming for the frontier sciences; it seems to us, therefore, that some thought should be given to the problem of nurturing the mixed sciences. Biochemistry, geophysics, and geochemistry all have niches in one or more research institutions: biogeochemistry may properly belong to geochemistry, but at all events it deserves to be considered on its own merits.

Occurrence of Trace Elements

If we consider the whole of the earth's crust, including all living things, we find that over 90 per cent is made up of seventeen elements: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium, hydrogen, titanium, chlorine, phosphorus, manganese, carbon, sulfur, nitrogen, and fluorine. Other elements are found in local concentrations, principally as isolated minerals or ores. Nevertheless, in nature it is exceptional to find either living matter or large homogeneous

bodies of the earth's crust in which the above seventeen elements do not predominate to approximately the same extent. Other elements normally occur only in amounts which until recently could not be estimated in the course of routine chemical analyses on samples weighing only a few decigrams: they were frequently recorded as "trace." Today amounts of many of these rarer elements can be satisfactorily estimated, even on small samples; in many instances the term "trace" is no longer either accurate or necessary. Furthermore, some of the seventeen elements may themselves occur as trace elements, examples of which might be chlorine, nitrogen, and fluorine in most rocks; aluminum and titanium in most plants; and silicon, aluminum, and manganese in animals. The term "oligoelement," originally proposed by Gabriel Bertrand for the trace elements, actually might be more appropriate, for *oligos,* in Greek, means "a little of." But it seems probable that geochemists and biogeochemists will continue to use the terms "trace" or "minor" elements, which by repeated use have acquired a significant connotation.

Recently in this journal Bert L. Vallee described what may be termed the receiving end of the natural history of the trace elements. The giving end has been studied by the geologists, who have been able to throw some light on the problems concerned with the origin and supply of these elements in the earth's crust. In some instances the geologists have been able to make use of biological receivers or concentrators in solving their own difficulties. Biologists are beginning to make use of these studies in reverse. Studies of fluorine in dental caries, of iodine in goiter, of cobalt in "falling sickness," have all shown that doctors and agriculturists can profit by effective collaboration with geologists. It is in the task of uniting and coordinating our knowledge of trace elements as they relate to geology on the one hand and biology on the other that biogeochemistry can make its unique contribution.

Quite apart from their scientific value, trace elements are of great practical importance. Many of them normally occur only in a dispersed state and are seldom found in concentrated forms. The best hope of finding even relative concentrations and of obtaining effective recovery of some of these trace elements lies in possessing an adequate knowledge of the laws that govern their geochemical distribution and migration in the earth's crust.

In the past thirty years, extensive investigations have been made on various rock samples representing large areas of the earth's crust, and on meteorites, both with regard to their major constituents and with special reference to their content of rare or trace elements. It appears that no element occurs in extraordinarily low amounts relative to its immediate neighbors in the periodic table. The only exceptions to this generalization are certain inert gases that may have wandered away into intersidereal space, radioactive elements, and some elements such as promethium that are known only in artificially prepared radioactive form. Relative abundance has nothing to do with practical availability: except for some of the most common elements, the relative abundance of an element in the earth's crust is determined largely by its presence in minute amounts in great volumes of the common rocks rather than in concentrations such as those from which we obtain economic production. For example, scandium and gallium are both much more abundant in the earth's crust than either silver or antimony, but they are much rarer in a concentrated state, and very expensive to extract from any minerals with the exception of a few that are extremely rare. A simple calculation will show that a mountain containing one ounce of copper per ton of rock, a fairly common content, actually represents much more of this metal than many a large ore body.

Whether or not we accept the theory that our material world was originally a huge ball of fire, the fact remains that many data concerning the relationships of igneous rocks in the earth's crust can be explained satisfactorily by magmatic differentiation. Huge masses of igneous rocks appear to have been formed from cooling melts, or magmas, from which those components with higher melting points tended to separate out early, and those with lower remained liquid until later.

Thermodynamically the minor or trace elements in a mixture have little influence on its equilibria; furthermore, the fate of the trace elements will be dictated to a large extent by the fate of the major constituents. To be accurate, we must admit that there tends to be a little of everything in everything. To put this differently we may say that the segregation of trace elements in rocks is far from perfect. If we remember that the liquid phase is extremely viscous we can realize that an element present in amounts of the order of one part in one thousand millions—the average order of magnitude of many trace elements—is lucky to gather together at all, and even if it does the resulting "drop" does not stand much chance of separating by gravity and accumulating, and even less chance of giving us an identifiable mineral. This means that no rock, however deficient with respect to trace elements, is absolutely unable to support the mineral needs of some form of life.

Nevertheless, most trace elements are found in specific rocks, and particularly in specific minerals, where their presence can be explained by general crystallographic laws. Modern knowledge of crystals has not only simplified the definition of crystal structure but has also done away with the need for knowing both end members of an isomorphous series. We do not need to know about the properties, or even the existence, of nickel orthosilicate to predict that nickel can enter peridotite: it is enough to know that divalent magnesium and nickel ions have the same radius, 0.78 A, and that they can exist under the same oxidation-reduction conditions.

Where trace elements are involved in isomorphism, high dilutions are implied, and they therefore have little tendency to crystallize. We may state this in another way by saying that an ion has to go very well indeed into a crystal structure to prefer it to a liquid, where there is an abundance of similarly sized ions into which it may still fit extremely well. For instance, most of the nickel in a magma will precipitate with the ultrabasic silicates, but cobalt will not follow so readily because its ionic radius is 0.82 A, and thus it fits well with iron in the liquid, iron having a radius of 0.83 A. Consequently, although in an original magma there is more nickel than cobalt, quite early in the course of magmatic differentiation there is as much cobalt as nickel left, and cobalt may even be dominant in the latest stages.

These physicochemical tendencies give rise to two interesting consequences. Some elements are characteristic, as trace elements, of specific types of rocks and may be concentrated where these rocks weather. Thus nickel residuals may result from the weathering of a peridotite, and tin from a pegmatite. These same trace elements may occur in greater concentrations in plants growing either on these rocks or on soil derived from them. Thus in some places a specific rock type may be detected, even though it is deeply mantled with overburden.

In a typical series of magmatic rocks—peridotite, pyroxenite, gabbro, diorite, and quartz diorite—some elements, such as nickel and chromium, concentrate in the earlier rocks; others, such as iron and vanadium, are found in the middle of the series; many remain in the residue until most of the magma has crystallized. The last elements remain in the magma usually because they cannot fit in the silicates, sometimes because they have an unusually small- or large-sized ionic radius, as is the case with beryllium, boron, and cesium. Included here are many of the ingredients found in pegmatites. In addition to having too large or too small an ionic radius an element may have a high valency and thereby be prevented from entering $(SiO_4)^{-4}$ tetrahedra, $(AlO_6)^{-9}$ octahedra, or apatite structure. This is true of columbium, tantalum, zirconium, tin, and the rare earth metals, which will form distinctive minerals in the more acidic rocks, especially pegmatites. Some elements, such as copper and zinc, appear to be spread throughout the series.

In sedimentary rocks there tends to be an equalization of trace elements, probably because they are derived from many different sources. Selective concentration of some elements may occur, however. In particular, living organisms may contribute to the formation of some sedimentary rocks, which may as a result retain certain elements preferentially. Between the death of the organisms and the fossilization of their remains in a formation they may have been instrumental in fixing, possibly by means of the sulfidic products of their decay, relatively large amounts of one or more of the less common elements from mineralized water or from sea water. This process can even give rise to commercial ore, as in the Mansfield copper-bearing schist in Germany; or it may cause agricultural trouble, as in the case of selenium in some North American shales. On the whole, sediments tend to have a better balanced trace element composition than volcanics. In British Columbia accumulating evidence suggests that, other factors being equal, sedimentary formations support a better forest growth than do the eruptive rocks. This might be caused by trace elements. Here is a fruitful field for further research.

It is tempting to suppose that, where either petroleum or coal has been formed from a closely related source, the content of trace elements in the deposits might, in one horizon at least, have been fixed in similar proportions. If so, this may provide a means for determining the relationship between coal or petroleum horizons where the beds or pools are not too far distant and where paleontological and other evidence provides no clue. Relatively little work has as yet been reported in this field.

Trace Elements in Plants

Trace elements can pass into vegetation either from rock or from soil derived from rock. The major elements occurring in the soil are taken up by plants at widely different rates: proportionally, much less aluminum and silica and much more of the alkali metals, chlorine, and sulfur are to be found in plant ash than in the soil from which they have fed. On the other hand, the less com-

mon elements are present, in absorbable form, in quantities usually well below the maximum intake of which plants are capable. Thus rejection of an excess of the more common elements leads to an apparent concentration of trace elements in plants. This is by no means a passive phenomenon, and some specificity is shown. For example, ash of a white birch may contain from five to ten times as much zinc as ash of an alder growing on the same spot; conifers such as spruce or hemlock may contain ten to twenty times as much manganese as deciduous trees growing in intimate association with them. If sufficient care is taken to compare the same organs of similar age in the same species, it is possible to show that their trace element content depends on the supply of the elements provided by associated rock or by soil derived therefrom. This fact may be of great importance in large areas where glacial material or dense vegetal cover prevents geologists from obtaining ready access to underlying rock. In short, if there be some proportionality between trace elements in plants and the original supply in underlying rocks, then the trace elements will vary relatively and absolutely in groups of plants, and this variation should be susceptible of correlation with the underlying rock formations. Thus, theoretically, it becomes possible by analyzing vegetation to determine what kind of rock lies under a given tree.

In some cases the influence of a particular rock type may be so strong that it affects the character of all the vegetation and direct detection becomes possible. For example, ultrabasic rocks usually provide meager support for vegetation; limestone tends to produce a special flora; in some areas of Australia geological boundaries may be accurately determined solely by variations in the vegetation.

Much has been said about "indicator plants" which grow at or near mineralized outcrops, and undoubtedly direct relationships do exist between certain species and the mineral content of underlying rocks. Unfortunately, attempts at systematizing the data show that specificity is less prevalent than might be expected, and in Canada, glacial drift tends to complicate and obscure most biogeochemical relationships.

In spite of the apparent concentrating power of vegetation, the supply of trace elements in a soil may fall short of the actual needs of a plant. This is a common occurrence on reclaimed lands, which were originally too poor for cultivation, as well as on exhausted lands. Lack of zinc and copper has caused trouble in the United States, particularly in growing citrus fruits in California. In some sections of Europe, huge sugar-beet crops, season after season, have removed from fertile soil sufficient boron to bring about a shortage of this element, thus leading to a deficiency disease. Deficiency of trace elements is a current problem in some glaciated areas, because plants there have to live on the toughest and least easily decomposed pieces of rock, which alone have been able to survive the grinding action of ice. In some wheat from glaciated areas we have observed very low content of zinc and manganese.

Mineral deficiencies can affect the animals living on such land; B. L. Vallee has already referred to copper and cobalt as examples. Human food supplies in most parts of the Western world come from such diverse sources that mineral deficiencies escape detection, but in areas where farmers live entirely, or largely, on their own products and have a dominantly vegetarian diet, they may—and such cases have been recorded in British Columbia—suffer from mineral deficiencies. In the United States cases of selenium poisoning have been recorded as a result of crops growing over rocks that are abnormally high in selenium.

Trace Elements in Ore Minerals

In recent years secondary constituents of ores have been found to furnish important data on the conditions surrounding their formation. Previously these trace elements were neglected because they were present only in small amounts and because they usually had little or no commercial value. Now we believe that sphalerite formed at high temperatures is rich in cobalt and manganese; sphalerite formed at low temperatures is rich in gallium; and indium is characteristic of intermediate temperatures. Data are too few and too inconclusive as yet for any general system to be determined. The results already attained are decidedly encouraging, however, and should serve to stimulate more definitive studies of the trace elements in ores and associated minerals.

Mineralization can provide an excess of trace elements in the surrounding rocks, and the excess may be used in attempting to track the metal to its source. Started by the Scandinavians, notably Rankama, Palmqvist, and Th. Vogt, such methods have received considerable attention in the USSR, where the work of Sergeev has been outstanding. During the past decade the techniques have been applied in North America, and Millman and Webb have made valuable contributions by their studies in West Africa.

Mineral deposits provide a "dispersion halo," which is characterized either by an excess of metal ions in the soil, or by particles of ore that are most

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resistant to weathering. Both conditions are apt to be conspicuous in the case of a shallow residual soil. Between this halo and the sea lies a "train of dispersion," which can be quite dense in the neighborhood of a deposit. The dispersion train consists mostly of ions in flowing water or of particles of minerals in creek beds. Factors that cause the train of dispersion to form distort the halo itself, which normally does not appear as a simple shadow of the deposit. On a horizontal projection it can look like anything from a delta to a narrow flow, and in vertical projection it can resemble a mushroom.

In practice one may proceed along a dispersion train not only by the old method of panning up creek beds but also by analyzing the water for very small amounts of metal. Similarly, for the dispersion halo, it is possible not only to look for visible amounts of minerals by panning the soil, but also to obtain results by analyzing either the soil or the plants growing on it for the metals being sought.

The last technique is particularly valuable in glaciated areas where there is no residual soil, and where the rock may be covered by ten to fifty feet of overburden—in places even more—which has no direct relationship to the underlying formation. Unless there is an impassable barrier of hard glacial clay (and even glacial clays do not seem to be entirely impervious to migrating ions), the roots of trees must reach either the rock or products derived from it, in order to obtain much of their mineral food. A large excess of metal content in the rock will be reflected by an excess in the trees, and in our work we have successfully removed both gold and silver from the tips of young trees such as Douglas fir and poplar.

Unfortunately, but quite understandably, most investigators have done their preliminary work under exceptionally good conditions, and later investigations have failed to show the same large differences between trees above ore and trees above controls. In our own experience we now look for only 50–100 per cent in excess of normal for most trees growing over copper or zinc mineralization. For satisfactory results it became essential to discover which organs contain the most regular content of the metals being sought, and then to find analytical methods of sufficient accuracy and practicability to enable each particular problem to be solved. Thus biogeochemical prospecting has turned out to be less simple than it at first appeared. Nevertheless, in many localities in North America, biogeochemical methods are the only means of obtaining evidence of mineralization without drilling or actually removing the heavy overburden by ground sluicing or bulldozing. In one recent investigation in which one of us was involved, the cost of mechanical trenching proved—at the preliminary stage of prospecting—to be prohibitive. Biogeochemistry, however, revealed anomalies that justified drilling, which in turn revealed mineralization.

This discussion represents all-too-brief an introduction to the relatively little-explored field of geochemistry and biogeochemistry. Investigations in these fields are proceeding rapidly in many parts of the world, however, and the attached bibliography may serve as a guide to some of the stimulating work that has appeared in print during recent years. Biogeochemists may have a part to play in integrating various sciences in much the same manner that geographers have sought to integrate social studies with the natural sciences.

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Urbanization without Breakdown: A Case Study

OSCAR LEWIS

The author, who is a member of the staff of the Department of Sociology and Anthropology at the University of Illinois, has long been interested in the social and economic aspects of rural Latin-American culture (see Life in a Mexican Village: Tepoztlán Restudied, Sci. Monthly, 74, *368 [1952]). Dr. Lewis will leave next month for India, where he will be on a two-year leave of absence from his university post. The project on which he will work, jointly sponsored by the government of India and the Ford Foundation, is a vast experiment in controlled culture change. Centers will be set up in various provinces, in which Indian personnel will be trained in modern extension service methods. Dr. Lewis will help to evaluate the progress of this work.*

THIS is a preliminary work report on a research project on urbanization in Mexico City. The research is an outgrowth and continuation of my earlier work in the village of Tepoztlán. In brief, we attempted to learn what happened to individuals and families from the village of Tepoztlán who had gone to live in Mexico City.*

Before presenting some of the preliminary findings, I should like to indicate how our work is related to other studies in the same field. In the first place, it should be noted that there have been very few studies of the sociopsychological aspects of urbanization in Mexico or other Latin-American countries. Urban sociology in Mexico has lagged behind developments in some of the other social sciences. The data most nearly comparable to ours are to be found in the rural-urban migration studies done by rural sociologists in the United States. These studies have been primarily concerned with the causes, the rate and direction, and the amount of migration, factors of selectivity, and occupational accommodation.

To the extent to which they have dealt with the adjustment of migrants in the city, the findings have on the whole highlighted the negative aspects, such as personal maladjustment, breakdown of family life, decline of religion, and increase of delinquency. The total picture has been one of disorganization, sometimes referred to as culture shock incident upon city living. One common theoretical explanation of these findings has been in terms of the change from the primary group environment, which is generally characterized as warm, personal, moral, and intimate, to a secondary group environment, which is described as cold, impersonal, mechanistic, nonmoral, and unfriendly.†

The preliminary findings of the present study of urbanization in Mexico City indicate quite different trends and suggest the possibility of urbanization without breakdown. They also suggest that some of the hitherto unquestioned sociological generalizations about urbanization may be culture-bound and in need of re-examination in the light

* I am grateful to the Graduate Research Board of the University of Illinois for financial assistance on this project. The field research in Mexico City was carried out in the summer of 1951 with the aid of a group of students from the University of Illinois.

† The tendency to view the city as the source of all evil and to idealize rural life has been corrected somewhat by the work of rural sociologists in recent years. We are no longer certain that rural society per se is nearly as Rousseauan and anxiety-free as we once thought. Studies by Mangus and his colleagues suggest just as high an incidence of psychosomatic illness among the farm population of portions of Ohio as in urban areas (see A. R. Mangus and John R. Seeley. *Mental Health Needs in a Rural and Semirural Area of Ohio,* Mimeo. Bull. No. 1951. Columbus: Ohio State Univ. [January 1947]). Moreover, a study by Goldhamer and Marshall suggests that there has been no increase in the psychoses (and, by inference, also in the neuroses) over the past hundred years in the state of Massachusetts, a state that has undergone considerable industrial development during this period (see Herbert Goldhamer and Andrew W. Marshall. *The Frequency of Mental Disease: Long-Term Trends and Present Status.* The Rand Corp. [July 1949]).

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of comparative studies of urbanization in other areas.‡ Some of our generalizations about the differences between rural and urban life also need to be re-examined. It should be recalled that direct studies of the urbanization process itself are difficult, and most studies have been indirect and inferential. Sociological generalizations about the differences between rural and urban society have been based largely on comparative statistical data on the incidence of crime in rural and urban areas, on birth, fertility, and death rates, size of family, educational opportunities, and social participation. As Ralph Beals has recently pointed out, ". . . sociologists paid much more attention to urbanism than to urbanization."§ Moreover, we know very little about the psychological aspects of urbanization as it affects specific individuals and families.

Perhaps one of the difficulties in this field has been the inadequate methodology. There is not, to my knowledge, a single study that has followed up migrants from a rural community which had first been the subject of intensive analysis on the social, economic, political, and psychological levels. An adequate research design for the study of the sociopsychological aspects of urbanization would require a project consisting of three phases: a well-rounded study of a rural or peasant community, including intensive family and psychological studies; locating families from this community who have gone to live in the city; an intensive study of these families in the city.

The present research has attempted to conform to this design. The first phase was completed some time ago with a study of the village of Tepoztlán. The second and third phases were begun last summer in Mexico City.

The specific objectives of the research were conceived as follows: (1) to study the process of urbanization directly by analyzing the changes in custom, attitudes, and value systems of Tepoztecan individuals and families who had gone to live in Mexico City; (2) to compare family life and interpersonal relations of selected urban families of Tepoztecan origin with those of the rural community from which they had migrated; (3) to relate our findings to the more general theoretical findings and problems in the field of culture change.

The study was planned on two levels. First, we wanted to do a broad survey of all Tepoztecan families in Mexico City and obtain data for each family on such items as date of and reasons for leaving the village, size of family, kinship composition of the household, the extent of bilingualism (Spanish and Nahuatl), the general level of living, the religious life, the *compadre* system, curing practices, and the life cycle. For most of these items we had rather full data on the village of Tepoztlán; these data could therefore be used as a base line from which to analyze the nature and direction of change.

Second, we planned to do intensive studies of a few selected families representative of the different lengths of residence in the city and of different socioeconomic levels. Other variables that might become significant in the course of the study were also to be taken into consideration.

We located 100 Tepoztecan families in Mexico City and interviewed each family at least once. Sixty-nine families were interviewed twice, and 10 of these were interviewed ten times. The quantitative data in this paper are based on the 69 families for which we had the fullest data. The major factor in our inability to gather more information on the remainder of the families was lack of time. On the basis of the data obtained in the one interview with each of the 31 families, it appears probable that our total picture would not have been appreciably changed. The fact that the 69 families were distributed in many different sections of the city and that they represented distinct socioeconomic levels further insures against an inadvertently loaded sample.

The city families were located with the help of our informants in Tepoztlán, many of whom had friends and relatives in the city. But most of the families were located with the aid of officers of the now-defunct Colonia Tepozteco, an organization of Tepoztecans in Mexico City, which kept a list of the names and addresses of Tepoztecans living in the city. We have reason to believe that the 100 families we located represent approximately

‡ Theodore Caplow's excellent article on "The Social Ecology of Guatemala City" (*Social Forces*, 28, 113 [December 1949]) suggests the provincialism of earlier sociological ideas about the nature of the city. Caplow writes, "The literature of urban geography and urban sociology has a tendency to project as universals those characteristics of urbanism with which European and American students are most familiar . . . there was until recently a tendency to ascribe to all cities characteristics which now appear to be specific to Chicago . . ." (p. 132). Caplow raises the question whether "much of the anarchic and unstable character attributed by many authorities to urban life in general is not merely a particular aspect of the urban history of the United States and Western Europe since the Renaissance" (p. 133).

§ Ralph Beals. "Urbanism, Urbanization, Acculturation." *Am. Anthropol.*, 53, (1), 5 (January–March, 1951).

90 per cent of all Tepoztecans living in the city.

It should be noted that field work in the city is in many ways more difficult, more costly, and more time-consuming than in the village. The Tepoztecan families were scattered in twenty-two different *colonias*, or neighborhoods, extending from one end of the city to the other. Much time was lost in traveling to and from the homes, in making appointments for interviews (only one of the families had a telephone), and in establishing rapport. Often we would spend an entire morning calling on two or three families, only to find people out or otherwise unavailable. Moreover, we did not have the advantage of working through community leaders, of becoming familiar and accepted figures in the community, or of utilizing neighbors—and village gossip—as sources of information.

The earliest contacts between Mexico City and Tepoztlán probably resulted from trade. A small number of Tepoztecan merchants regularly sold their products (mainly hog plums and corn) in the Merced, Lagunilla, and Tacubaya markets. Consequently, some of the earliest migrants of whom we have record settled near these markets, and to this day there are small concentrations of Tepoztecan families around the markets.

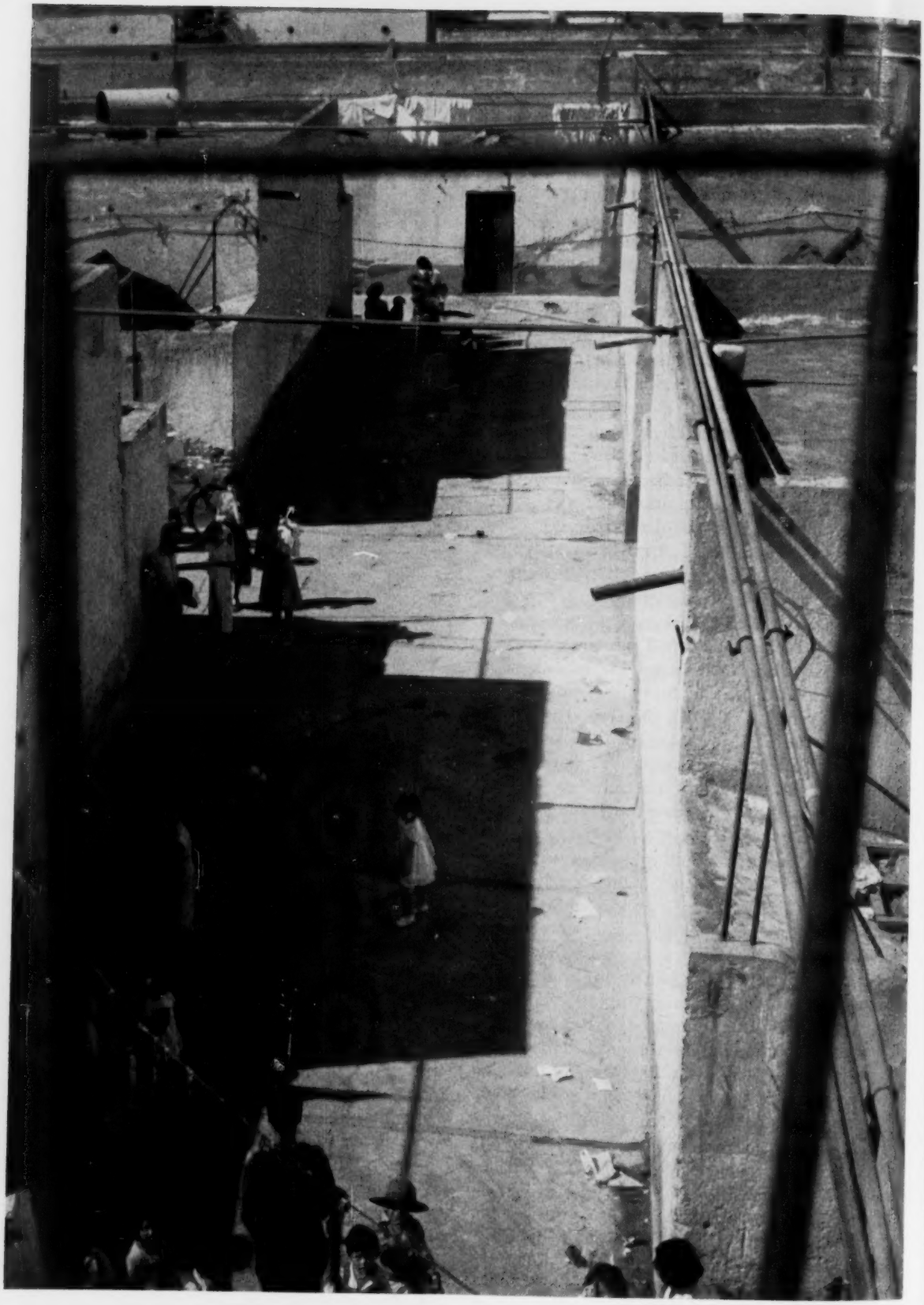
Our study revealed that the Tepoztecan families now living in Mexico City came in three distinct periods of migration. The first was prior to the Mexican Revolution of 1910; the second was during the Revolution, from about 1910 to 1920; the third since 1920. The motives for migration and the number and quality of migrants, as well as their social composition, show interesting differences for each of these periods.

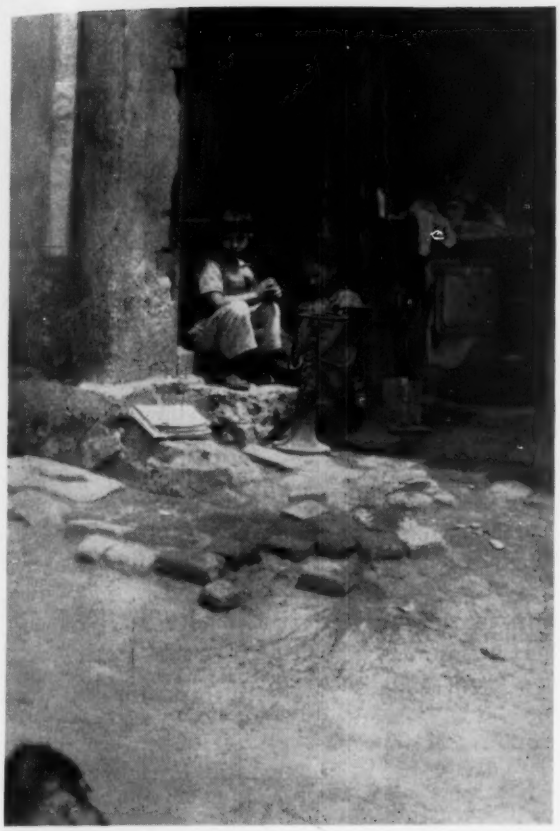
During the first period only young men left, their primary motives being to get a higher education and to seek better employment opportunities. These early migrants were generally poor young men related to the best families in the village. We located 15 individuals who left during this period. In general these early migrants made good, economically speaking. Some became professionals and have achieved important positions in the city. Many became the intellectuals who later formed the core of the Colonia Tepozteca, which was to play such an important part in community affairs.

The second period was one of forced migration, when hundreds of Tepoztecans left the village, generally as family units, to escape the ravages of the civil war. The earliest ones to leave during this period were the *cacique* families who fled before the threat of the Zapatista revolutionaries. Later, when the village became a battleground for opposing forces, people from all social levels fled. It is estimated that by 1918 there were approximately a thousand Tepoztecans in the city, and, according to our informants, approximately 700 attended one of the early meetings preceding the formation of the Colonia Tepozteco. Most of these migrants returned to the village after peace was established. Many of those who remained were the conservative, wealthier families who had been ruined by the Revolution. About 65 per cent of the families we studied came to the city during this period.

Back-yard scene, Tepoztecan home, Mexico City, is typical of back yards the world over.

The striking thing about migration during the third period is the relatively small number of migrants. Only 25 per cent of our families came during 1920–50. We find a wider variety of motives for migration than formerly, but the two most important seem to be improved educational and economic opportunities. During the later twenties and early thirties, however, a number of men left because of the intense political strife which flared up in the village. Again we find that the young men predominated in the exodus, but now there were also young women, who came either to attend school or to serve as domestics. In all cases during this period, the migrants came to live with relatives





Patio of Tepoztecan home, Colonia Portales, Mexico City.

or *compadres*. There was apparently a sharp increase in the number of migrants to the city toward the latter part of this period, particularly after the road was built in 1936.

The figures for Tepoztecans in Mexico City are not an accurate index of the total migration from the village. This was established by a study of all the cases that have left the village since 1943. Of 74 cases that left, only 41 went to live in Mexico City; the remainder went to other villages and towns. Of the 41 in Mexico City, there were 23 single males, 16 single females, and one married couple. Over 90 per cent were from two large barrios in the center of the village.

Tepoztecans in the city live in three types of housing: the *vecindad,* the apartment house, and the separate, privately owned dwelling. The *vecindad* represents some of the poorest housing conditions in the city. It consists of a series of one-story dwellings arranged around a courtyard. Often there is a communal water fountain in the center and one or two toilets for a settlement of 25 families. In a few cases there is piped water in each apartment. One of our families lived in a *vecindad* of 150 families—practically a small community in itself. The rentals varied from 25 to 65 pesos ($3–$8) a month. Forty-four per cent of Tepoztecan families live in *vecindades.* The dwellings are generally small, usually consisting of two rooms.

The apartment house provides much more privacy and represents a distinctly higher standard of living. Sixteen per cent of the families lived in apartment houses, at rentals ranging from 65 to 300 pesos a month. Professionals and skilled laborers live here—typical Mexican lower-middle-class families. The apartments are better constructed than the *vecindades* and have more and larger rooms.

Privately owned homes were dwellings for 28 per cent of the families. There was a wide range in the styles, size, and property value of these houses. Some were one- or two-room wooden shacks built on tiny lots on the outskirts of the city; others were modern eight- or ten-room buildings, with enclosed private gardens and patios, located in a

Patio in a Colonia Portales home reflects the peasant's love of growing things.

Many former residents of Tepoztlán live in low-quality housing such as the *vecindad* shown at the left.

thriving middle-class neighborhood. Home ownership is therefore not a good index of wealth or class position.

The average size of Tepoztecan households in the city was somewhat larger than in the village—5.8 as compared to about 5 (Table 1).

The composition of the household shows about the same pattern as in the village except that there is a slightly higher percentage of extended families living in the city (Table 2). In contrast to Tepoztlán there were no cases of persons living alone or of unrelated families living together. There is probably greater economic pressure for families to live together in the city than in the country. In Tepoztlán, if young couples do not get along well with the in-laws and wish to live alone, they can almost always find someone who has an empty house that can be used rent-free. The same is true of old people and widows, who manage to eke out a living with garden produce and by raising chickens or pigs.

We found very little evidence of family disorganization in the city. There were no cases of abandoned mothers and children among our 69 families studied nor was there a history of separation or divorce in more than a few families. Families remain strong; in fact, there is some evidence that family cohesiveness increases in the city in the face of the difficulties of city life. In Tepoztlán the extended family shows solidarity only in times of crisis or emergency. Although there is more freedom for young people in the city, the authority of parents shows little sign of weakening, and the phenomenon of rebellion against parental authority hardly exists. Nor are the second-generation children ashamed of their parents. Perhaps this can be explained by the general cultural emphasis upon respect for age, authority, and parenthood. Similarly, we found no sharp generation cleavage in values and general outlook on life.

As might be expected, the general standard of living of Tepoztecan families in Mexico City shows upward movement as compared with Tepoztlán. Thus, 78 per cent of our city families had radios as compared to about 1 per cent in the village; 83 per cent had clocks as compared to about 20 per cent in the village; 54 per cent had sewing machines as compared to 25 per cent in Tepoztlán; 41 per cent reported buying a newspaper with some regularity as compared to 6 per cent; 3 of our 69 families owned cars in the city; there were no car owners at the time of our Tepoztlán study. In the city all slept in beds; in the village only 19 per cent slept in beds in 1940. However, there seemed to be more crowding in the city, especially among the poor families, than in the village. I found cases, in *vecindades,* of 10 people living in one room and sharing two beds. A similar situation holds in regard to toilet facilities. All Tepoztecan families in the city had some toilet facilities, but we found cases where 15 families shared a single toilet, and in other instances there was a semienclosed toilet in the kitchen. From the point of view of hygiene, it is doubtful whether this was an improvement over the orchards of Tepoztlán.

The diet of the city families is similar to that of the village except that there is greater variety, depending upon income. The city dwellers all enjoy Tepoztecan cooking and continue to make *mole* on festive occasions. They strongly prefer Tepoztecan *tortillas,* and many continue to prepare beans with *epazote,* as in Tepoztlán. About 80 per cent of the families continue to use the metate and *meclapil,* especially for preparing fiesta meals. A few buy corn and make *tortillas* at home; a larger number buy mill-ground corn or masa; a still larger number buy ready-made *tortillas.*

The Tepoztecan custom of having household pets continues in the city. Fifty-four per cent of the

Mexican housewife at home.

TABLE 1

NUMBER OF PERSONS PER HOUSE SITE, TEPOZTLÁN AND MEXICO CITY

No. of Persons per House Site	Percentage of House Sites, Tepoztlán	Percentage of House Sites, Mexico City
1–5	44.2	41
6–10	52.5	53
11 and over	3.3	6

families owned a pet—dogs, cats, or pigeons, and 2½ per cent owned either chickens or pigs or both. Most of these families lived in privately owned homes.

The religious life of Tepoztecans in Mexico City appears to be at least as vigorous as in Tepoztlán. Again, the evidence does not support the findings of rural sociologists in this country to the effect that there is a decline in church attendance and religious practices when farm people move to the city. In our study it is not so much a matter of becoming more or less religious, but rather of a change in the content and form of religious expression. Specifically, it is a matter of becoming more Catholic and less Indian.

In general, the city Tepoztecans follow the Roman Catholic tradition more closely. The village belief that El Tepozteco is the son of Mary is no longer held and is regarded as backward and superstitious in the city. Tepoztecans in the city tend to send their children more regularly to Sunday School to learn doctrine, to take first communion, and to attend mass. Confession is as unpopular among city Tepoztecans as in the village, but probably occurs more often.

Mexico City, as the center of the Catholic Church in Mexico, has better organized and better staffed associations, which carry on intensive programs of indoctrination. In many *vecindades* we found religious shrines, usually of the Virgin of Guadalupe, and all residents are expected to honor them as the protector of the *vecindad,* to lift the hat in passing, to cross themselves, and to partake in the collective prayers organized by some enterprising member of the *vecindad.* That social control is strong can be seen from this statement by an informant: "If one does not salute the Virgin, the janitor and all the old women of the *vecindad* begin to call one a heretic and throw dirty looks."

TABLE 2

KINSHIP COMPOSITION BY HOUSEHOLDS—TEPOZTLÁN, 1943, AND MEXICO CITY, 1951

Type	Families in Mexico City (69) (Percentage of all Families)	Families in Tepoztlán (662) (Percentage of all Families)
Simple biological family	66.6	70
Biological family with married children and grandchildren	17.2	13.5
Married siblings with their children	2.9	2.1
Persons living alone	0	6.7
Unrelated families living together	0	.7
Miscellaneous	13.3	7.5

Even in the city villagers like to make their own *tortillas.*

Such shrines are also found in some of the factories in which our informants worked. A few of our Tepoztecans who are bus drivers tell of the requirement to carry images of San Cristobal, the patron saint of their union. They also tell of religious pilgrimages organized by the unions. One Tepoztecan explained that he had never bothered about the Virgin of Guadalupe when he was in Tepoztlán, but since working in the city has gone on two union pilgrimages. This same informant, who as a child in the village had recieved no training in doctrine classes, had no first communion, and rarely was obliged to attend mass, now attends

mass frequently, consults a priest about his economic and domestic problems, and, thanks to the perseverance of Acción Catolica, regularly sends his four children to Sunday School.

As another example of the increased activity of, and the greater identification with, the church is the fact that several of our city informants draped their doors with black crepe to mourn the death of a bishop of the church. In Tepoztlán it is doubtful whether the death of the Pope himself would lead to such action.

There are some differences in church organization in the city which affect participation of Tepoztecans. Unlike the village, there are no barrio *mayordomos.* Many of the tasks connected with the care of the images and the church, which in the village are assigned to members of the community or to the specific barrio, are carried out by paid church personnel in the city. Since many of these jobs were the work of men in the village, the net result is that in the city the men play much smaller roles in the religious life. Another difference is that the Tepoztecans in the city contribute less money to the church than in the village.

The system of *compadrazgo* continues to function among Tepoztecans in the city. Each Tepoztecan interviewed in Mexico City had *compadres,* godparents, and godchildren. With one or two exceptions the changes that *compadrazgo* has undergone represent an adaptation to urban life rather than a breakdown or even a weakening of the system.

A major change in *compadrazgo* in the city is the disappearance of several types of godparents known in the village—namely, the godfather of *miscoton,* godfather of the ribbon, godfather of *evangelio,* godfather of the scapulary, godfather of the Child Jesus. There is also much less use of the godfather of confirmation and the godfather of communion. The *compadrazgo* system is largely limited to the godparents of baptism and of marriage, thereby resembling the original Catholic practice as introduced by the early Spaniards and as practiced to this day in Spain.

The decline in the role of the godfather of baptism is another important change. In the city he is no longer consulted in the selection of the godparent of confirmation in the cases where this occurs. Moreover, in the city there is no *sacamisa,* thereby eliminating the role of the godparent of baptism in this ritual. The absence of the *sacamisa* is probably due to the unwillingness of the mothers to remain at home for forty days after the birth of the child, as is required in Tepoztlán. Another adaptation to city life is the delayed baptism. In Tepoztlán babies are baptized as soon as possible, often when only a few days old, almost always before three months. In México City baptisms in our families did not occur for 12 to 18 months and sometimes not for several years. This delay may be attributed in part to the lower death rate among infants born in the city and to a lessened anxiety about infant health.

Another interesting change in the city is the increased frequency with which relatives are selected as godparents. In Tepoztlán it is unusual to find relatives who are *compadres.* Most Tepoztecans consider this undesirable, for it conflicts with the basic notion of respect and social distance that should exist between *compadres.* In the city, where Tepoztecans find themselves without friends, they turn to relatives for godparents. Family ties are thereby reinforced by the ties of *compadrazgo.* But this changes the character of the *compadrazgo* relationship from a formal and ceremonial relationship to a more informal and personal one. The mode of address among *compadres* in the village

Some Tepoztecans in Mexico City are comparatively well-to-do. Here a Mexican schoolteacher sends her children off to Sunday School.

is always of *"Vd.–Ud."* In the city it is frequently merely a continuation of the form of address used prior to becoming *compadres.* Thus, in the city we find *compadres* addressing each other as *"tu–tu,"* *"Vd.–tu,"* and *"Vd.–Vd."* The *"tu–tu"* is used between brothers or sisters who have become *compadres.* The *"Ud.–tu"* is used when an uncle and nephew become *compadres.* In rural Spain we found the *compadre* system to be practically identical with the urban forms in Mexico.

Still another change in the system in the city is the custom whereby a man or woman will offer to be a godparent before the child is born. In the village one always waits to be asked in a formal manner. Since it might be taken as an insult to turn down an offer of godparentage, the net effect is to reduce parental control in the matter of selection. The obligations of godparents to godchildren and of *compadres* to one another are more clearly and specifically defined in the village than in the city. In the city there is much more familiarity between *compadres,* and a *compadre* may ask for almost any kind of favor.

Many Tepoztecan families in the city still use herbs for cooking and curing. In almost all the privately owned homes and in some of the *vecindades* common herbs such as yerba buena, *santa maria,* and manzanilla are grown in gardens and flowerpots. Herbs are used to cure colds, headaches, stomachache, toothache, and so on, much the way they are in Tepoztlán; however, city families tend to rely more upon patent medicines than do village families. Illnesses such as evil eye, *los aires,* and *muina* ('illness of anger'), for which there are no patent medicines, necessarily are cured by native herbs. In these cases it is not uncommon for city people to return to the village to be cured. It should also be noted that, when other illnesses do not respond to patent medicines or to medical treatment, the sick person may be taken to the village for rediagnosis and cure. One informant told of suffering a partial paralysis of the face and of being treated unsuccessfully by several doctors. Finally, a visitor from Tepoztlán diagnosed it as an attack of *los aires,* whereupon the patient went to the village and was promptly cured by means of appropriate herbs placed in a bag suspended around his neck. The daughter of another informant was stricken with poliomyelitis and despite hospital treatment remained paralyzed. Her father, in desperation, took her to Tepoztlán, where she was given a series of sweat baths in a *temazcal.* This treatment, according to her parent, brought about considerable improvement. Sometimes, in the hope that the local *curanderos* would "understand" the illness better, an incurably ill person may be taken from the city to the village, only to die there. Thus, not only do country people go to the city seeking cures, but the same process works the other way around.

In considering stability or change in the way of life of Tepoztecans in Mexico City it is important to realize that the ties between the city families and their relatives in the village remain strong and enduring for almost all the city families studied. They visit the village at least once a year on the occasion of the Carnaval. Many go much more often, to celebrate their own Saint's Day, to attend their barrio fiesta, a funeral, or the inauguration of a new bridge or school, to act as godparent for some child, or to celebrate a wedding anniversary, or the Day of the Dead. The ties with the village do not seem to weaken with increase in years away from it. On the contrary, some of the most ardent and nostalgic villagers are those who have been away from it the longest. Many old people expressed a desire to return to the village to die. Some men, who have been living in the city for thirty years, still think of themselves as Tepoztecans first and Mexicans second. Fifty-six per cent of the families studied owned a house in the village, and 30 per cent owned their private milpas.

The proximity to Tepoztlán, and the bus line which now runs to the village, facilitate visiting. The young people enjoy spending a weekend or a Sunday in their village. There is also some visiting from Tepoztlán to friends and relatives in the city.

In the past few years Tepoztecans in the city have organized a soccer team and play against the village team. The organization of a team in the city means that Tepoztecans from distant *colonias* must get together; however, the cohesiveness of Tepoztecans with their village is much greater than among themselves in the city. The Colonia Tepozteco has not been functioning for many years, having broken up because of factionalism within the organization.

In summary, this study provides further evidence that urbanization is not a simple, unitary, universally similar process, but that it assumes different forms and meanings, depending upon the prevailing historic, economic, social, and cultural conditions. Generalizations concerning urbanization must take these conditions into consideration. From our study of Tepoztecans living in Mexico City, we find that peasants in Mexico adapt to city life with far greater ease than do American farm families. There

Middle-class homes occupied by former Tepoztecans in Mexico City, and worker's home in a *vecindad*, Tacubaya. Community well in foreground.

is little evidence of disorganization and breakdown,‖ of culture conflict, or of irreconcilable differences between generations; many of the trends and characteristics found among these urbanized Tepoztecans are in direct opposition to those that occur among urbanized farm families in the United States. Family life remains strong in Mexico City. Family cohesiveness and extended family ties increase in the city, fewer cases of separation and divorce occur, no cases of abandoned mothers and children, no cases of persons living alone or of unrelated families living together. Household composition is similar to village patterns except that more extended families live together in the city. There is a general rise in the standard of living in the city, but dietary patterns do not change greatly. Religious life in the city becomes more Catholic and disciplined; however, men play a smaller religious role and contribute less money to the church in the city. The system of *compadrazgo* has undergone important changes, but remains strong. Although there is a greater reliance upon doctors and patent medicines to cure illness, city Tepoztecans still use village herbal cures and in cases of severe illness sometimes return to the village to be cured. Village ties remain strong, with much visiting back and forth.

In considering possible explanations for the above findings the following factors would seem to be most relevant: (1) Mexico City has been an important political, economic, and religious center for Tepoztecans since pre-Hispanic times. The contact with an urban, albeit Indian, culture was an old pattern, and has continued throughout recent history. (2) Mexico City is much more homogeneous than most large urban centers in the United States, both in terms of the predominance of Catholicism and of the cultural backgrounds of its people. Neither Mexico City nor Mexico as a whole has had much immigration from other parts of the world. The population of Mexico City therefore has very close ties with the rural hinterlands. (3) Mexico City is essentially conservative in tradition. In Mexico most of the revolutions have begun in the country. The city has been the refuge for the well-to-do rural families whose local positions were threatened. (4) Mexico City is not as highly industrialized as many American cities and does not present the same conditions of life. (5) Mexican farmers live in well-organized villages that are more like cities and towns than like the open-country settlement pattern of American farmers. (6) Finally, Tepoztlán is close to Mexico City, not only geographically but also culturally. The similarities between the value systems of working class and lower-middle-class families in Mexico City and those of Tepoztecans are probably much greater than those between, let us say, families from the hill country of Arkansas and working- and middle-class families from St. Louis or Detroit.

In conclusion, it must be emphasized that this study is still in its preliminary stage, and the findings are therefore tentative. The primary purpose has been to indicate a research design which might yield valid and reliable data for the understanding of the urbanization process.

It may be that Tepoztlán was not the best possible choice for this kind of study because of its proximity to Mexico City. It may also be that Tepoztlán is a special case from other points of view. Certainly we need other studies. We should have follow-up studies of migrants to the city from George Foster's Tarascan village of Tzintzuntzan, from Robert Redfield's and Villa Rojas' Maya village of Chan-Kom, from Julio de la Fuente's Zapotecan village of Yalalag, to determine to what extent the findings agree with those from Tepoztlán. It would also be important to have comparative studies of migrants to Mexico City, not from ancient and stable communities like Tepoztlán, but from plantation areas populated by poor and landless farm laborers.

‖ There is the possibility of other kinds of disorganization which might be manifested on a "deeper" level. In this connection it will be interesting to compare the findings of the Rorschachs given to the Tepoztecan families living in the city, with the findings on the Rorschachs from the village of Tepoztlán. It should also be noted that our findings for Tepoztecan families in Mexico City do not mean that there is no "disorganization" in Mexico City as a whole. A comparison of the statistical indices on crime, delinquency, and divorce, between urban and rural populations in Mexico, shows a much higher incidence for urban areas (see José E. Iturriaga. *La Estructura Social y Cultural de Mexico*. Fondo de Cultura Económica, Mexico, [1951]).

SCIENCE ON THE MARCH

THE CASTOR BEAN, INDUSTRIAL OIL SEED

NATIONAL emergencies have a tendency to place hitherto unimportant products in a temporary limelight, only to have peacetime conditions bring a return to obscurity. Illustrating this tendency is a little-known, yet promising oil seed, the castor bean, particularly adapted to our semiarid Western regions. Increasing uses hint that the end of the present national emergency may see more and not less of this industrial oil seed.

Uses of castor oil. The castor oil molecule has a unique and versatile character that enables the chemist to alter it easily to make it a useful, desirable, and even essential item. Unlike other oils, when castor oil is placed under a vacuum and heated in the presence of a catalyst, it gives up a molecule of water, creating what the chemist refers to as "conjugated double bonds." Oil thus treated is used in making decorative and protective coatings, which include paints, varnishes, and lacquers; the oil, or its derivatives, are used in plastics, rayon, nylon, asphalt floor tile, rubber insulations, fungicides, rubber products, soaps, imitation leather, and lubricants. One major castor oil producer sells 185 products made from castor beans and has about 100 other products in the development stage.

The Korean war has increased demands from defense agencies for castor oil, since it is used in jet-engine lubricating oil and other aircraft lubricants, hydraulic fluids, military all-purpose grease, and plastic-coated combat wire. In addition, castor oil is used as a plasticizer in the manufacture of military fabrics and explosives[1] and for other war purposes.

Practically all the raw beans used in the United States have come from Brazil, Manchuria, Africa, and India. These sources, which could never be considered certain, have fallen short of meeting even present needs, let alone possible future requirements. Present production of castor oil is approximately 150,000,000 pounds, which does not satisfy the demand (Fig. 1). U. S. production in 1951 was placed at a mere 20,849,011 pounds of hulled beans, which undoubtedly amounted to less than 10,000,000 pounds of oil. Estimates on the land area necessary to satisfy anticipated needs range from 100,000 to 1,500,000 acres, depending on the nature of the areas and the cost of production.

In 1951 castor beans were grown commercially in the United States as shown in Table 1.[2]

The plant. The native castor bean of the tropics is a robust perennial which bursts open and ejects (dehisces) its seed violently. Types introduced into the United States bloomed little the first year and

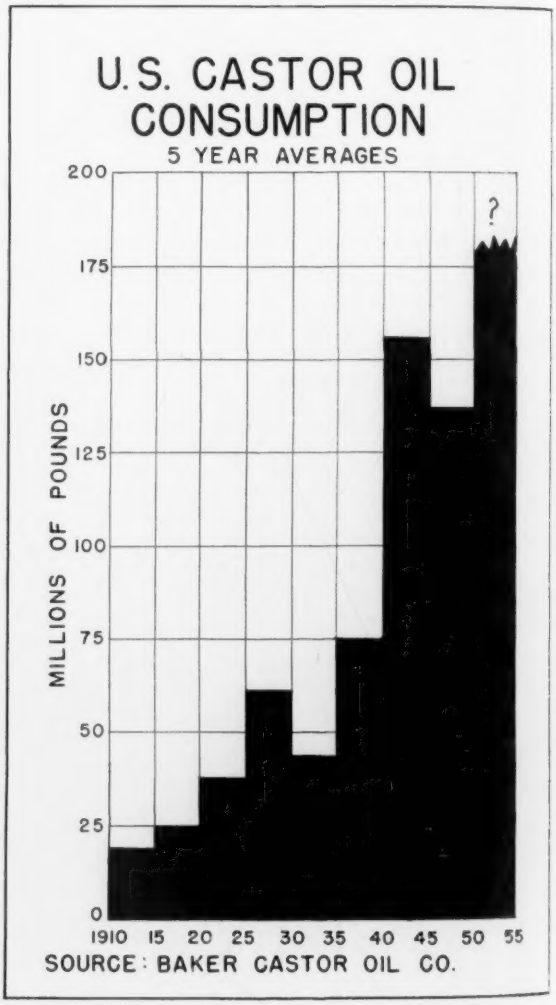


FIG. 1. U. S. consumption of castor oil, now an essential military raw material, has steadily increased to at least 150,000,000 pounds per year. The castor bean represents a possibly important addition to crop resources of the American Southwest.

TABLE 1

California	*Arizona*	*Oklahoma*	*Texas*
Antelope Valley	Salt River Valley	Altus	Brownwood
Imperial Valley	Yuma Valley	Ardmore	Chillicothe
Palo Verde Valley		Erick	Hereford
San Joaquin Valley		Henryetta	Stephenville
		McAlester	Vernon
		Stillwater	Wellington

were sensitive to frost, necessitating the breeding of new types. Whereas many castor plants grow to 12-foot heights and produce as many as 40 nodes during a growing season without blooming, several dwarf varieties are now available that flower at the sixth node, which is only about 10 inches from the ground (Fig. 2). Also, short, slender plants with spikes that resist shatter and dehiscence have been developed. These dwarf varities, adapted to specific regions in the United States, are being used on commercial acreages in those areas exclusively. Similar varieties that are less branched and somewhat taller are classed as intermediate. The common dooryard ornamental castor bean is the tall type, which is too robust for commercial culture.

A hot, dry climate promotes quick growth, causes seeds to set and mature rapidly, keeps fungus diseases at a minimum, and facilitates harvest and hulling. Since the plant continues to yield as long as it is permitted to grow, a growing season of 180 days or more favors greater production. Nevertheless, the castor bean cannot be classed as drought-resistant for a short period of stress, for lack of moisture can be very damaging to development and yield. Such characteristics made irrigated regions of the Southwest the choice locations for castor beans. As a nonirrigated crop, the castor bean finds a compromise between low humidity and adequate rainfall in Oklahoma and contiguous parts of surrounding states. The agricultural and commercial possibilities have been tested mainly under irrigation in the Imperial and San Joaquin valleys of California and on the U. C. Austin project in southwestern Oklahoma. Accelerated particularly by the present emergency, improved growing and marketing techniques have evolved, and the crop has been expanded into similar areas of the South and West.

Growing and harvesting. The castor bean crop is handled almost entirely by machine, with production techniques very like those used for cotton. Equipment ordinarily used for cotton or sorghum is easily adapted, and insect or disease control entails little expense. Special hullers and combines are now in production.

Castor beans are ordinarily planted on a fairly light-textured soil, preferably a sandy loam or similar type. Although high yields can be produced on heavy soils having proper drainage and sufficient irrigation, the crop does not do well on clay or sand or on very alkaline soil. The castor bean is not a legume.

Since yields are greatest when the crop has the entire frost-free season in which to produce spikes, planting takes place as soon as possible after danger of frost is past (early-cotton planting time). However, planting is profitable up to July 1, following spring harvest of small grains or potatoes.

The castor bean has a large seed and therefore requires plenty of moisture in a well-prepared seed bed during the germination period of 10 to 14 days. Various planting techniques are used in different regions, one common one being to plant the crop in rows, with an irrigation furrow opened between the rows in the same operation. This per-

FIG. 2. A dwarf variety of castor bean is produced in the Hereford, Texas, area. The small size allows harvesting by combine. Castor beans are within the prickly clusters in the center of the plant.

FIG. 3. Irrigation of castor beans in the Hereford area is accomplished by means of furrows between the rows. Withholding water causes leaves to fall, an aid to mechanical harvesting.

mits immediate irrigation and/or drainage and insures a uniform stand, which is essential to high yields (Fig. 3).

Although castor beans require somewhat less water than cotton, they cannot be allowed to suffer for water. After the initial irrigation to start growth, further irrigation is needed in midseason about once every 14 days, depending, of course, on weather and on soil texture. Since the crop drowns easily, standing water must be avoided, and furrow rather than flood irrigation is practiced.

Rows are spaced 38 to 40 inches apart, depending on the particular harvester to be used, with 75 to 125 plants per 100 feet. Being a row crop, the castor bean must be kept free of weeds and grasses. Usually no more than three cultivations are required, and a rotary hoe or spiked-tooth harrow is often used for the early one.

If the soil is low in fertility, a light application of nitrogen fertilizer at planting time and again at the last cultivation is used. Not much fertilizer is needed, for the crop is not a heavy feeder and is not hard on the soil; in fact, too much fertilizer may be detrimental by causing too much vegetative growth.

As with cotton, castor beans must be defoliated before harvesting. For postfrost harvesting, the crop is conveniently defoliated by the first subfreezing temperature. For prefrost harvesting, defoliation may be accomplished by withholding irrigation water or by application of chemical solutions by airplane. In California, where only dwarf varieties are used, the Massey-Harris combine harvests the crop, the seeds then being separated from the hulls by a portable huller at the field's edge. This is possible because of the large yields and dry atmosphere (Fig. 4).

Combines are also used in the Texas-Oklahoma areas, where dwarf varieties, or plants less than 6 feet tall, are raised. Although the taller plants and smaller yields of the Midwest formerly required hand-picking, a tractor-mounted stripper-harvester became available in 1951 (Fig. 5). In this area, growers deliver their harvested beans-in-hull to centrally located warehouses, where the hulling is done and from which the clean beans move to the mills.

Yields and farm uses. The first commercial acreage of castor beans grown in the San Joaquin Valley of California was harvested in 1950. Dwarf varieties, better adapted to mechanical harvesting, and therefore more productive than the old tall varieties, yielded 2500–3000 pounds per acre. Where castor beans are planted in the summer following winter crops, yields drop to about 1500 pounds per acre, but of course the land rental is shared by the other crop. The first experimental plantings in the Hereford area of the Texas Panhandle were expected to produce around 1000 pounds per acre. Acreage around the Altus and Vernon area of western Oklahoma averaged 604 pounds per acre in 1950. Since the national per acre average in 1951 was 332.33 pounds,[3] the potential production of these areas is quite significant.

All costs of production, including harvesting, hulling, and movement to consolidation points (but exclusive of land rental), are generally estimated to range from $10 to $60 per acre. With the government support price of 10 cents a pound and the 1951 market price of about 12.5 cents a pound, the economic attraction of the crop is obvious. At the present time, commercial growers are further assured of a satisfactory price in that

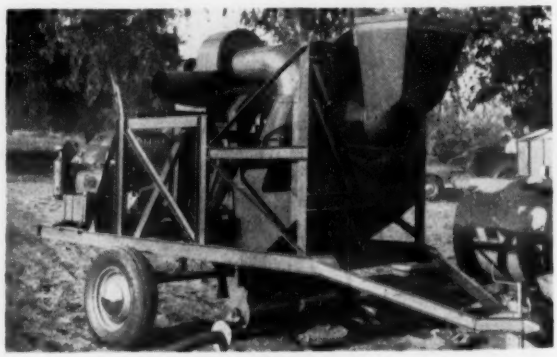


FIG. 4. In California, because of high yields and the dry atmosphere, a portable huller is used at the field's edge to separate beans from hulls after combining. In Texas and Oklahoma beans-in-hull are hauled to a central warehouse for further processing. (Photo by McMenamy Enterprises, San Diego, Calif.)

FIG. 5. A self-propelled combine is used to harvest dwarf varieties of castor beans in California, Arizona, and western Texas. As with cotton, plants are defoliated prior to combining. (Photo by Massey-Harris Company, Racine, Wis.)

almost all acreage is on a contract basis. In the Hereford area, a 400-acre experimental project was carried out in 1951, with farmers contracting to handle plots of 10–80 acres for certified seed production, with a cent a pound premium on certified seed.

Other secondary values are also of interest. The hulls are rich in nitrogen, having a fertilizer value equal to barnyard manure, and may be returned to the fields or sold for fertilizers. In the west Texas Panhandle near Matador, rows of castor beans are interplanted with rows of cotton, apparently in the belief that rodents and cotton insects will not live near the castor beans. At any rate, in the outer margins of crop production in the Southwest, the castor bean is looked upon as a cash crop that is immune to insect pests, that aids in crop diversification, and that can be produced by machine with little or no extra equipment.

Government interest. In 1951 a program for domestic production and procurement of castor beans on 90,000–100,000 acres was authorized by the Department of Agriculture at the request of the Munitions Board. This program, carried out by the Commodity Credit Corporation, was made available to farmers, who entered into contracts with the CCC, or with private companies under contract with CCC, in areas in Oklahoma, Texas, California, and Arizona for which adapted seed was available. The price to be paid these farmers was to be 10 cents per pound or the market price at time of delivery, whichever was the higher.

The CCC entered into contracts with manufacturers for the purchase of needed equipment and contracted for purchase of available seed for sale to farmers. Plans for 1951 called for planting about 27,000 acres of irrigated land in Arizona and California, 3000 acres of irrigated land in Oklahoma,

and 60,000 acres of dry land in Oklahoma and Texas. A goal of 78,000,000 pounds of castor beans was expected to produce 34,000,000 pounds of oil, plus a seed supply for 1952, but only 20,849,011 pounds of beans were harvested from 62,735 acres.

In November 1951 the Secretary of Agriculture announced an identical castor bean program for 1952—based, however, on 200,000 acres, of which 56,000 is to be irrigated and the remainder dry land. Production goals are set at 113,000,000–155,000,000 pounds of beans, from which 50,000,000–70,000,000 pounds of oil would be obtained.[4] Whereas three fourths of 1951 production was from California and Arizona, the greater part of the 1952 crop is expected to come from Oklahoma and Texas.

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LIBRARIES—STOCKPILES OR COMMUNICATION CENTERS?*

A FEW years ago Pierce Butler stated that civilization was based essentially on three processes: the discovery of knowledge, the conservation of knowledge, and the transmission of knowledge (*The Reference Function of the Library.* Univ. Chicago Press, 15 [1943]). The librarian is basically interested in the last two of these processes, the conservation and the transmission of knowledge, and he needs the help of the scientist, the writer, and the teacher in determining the extent and nature of his procedures and of his services to library users of all types.

Stockpiling, or conservation of knowledge, has been a major activity of libraries since their beginnings. Although each use of a book in a library presumably represents communication of knowledge, it is safe to say that only in relatively recent years have librarians given any real attention to the second vital function, the transmission of knowledge. But without this second function, libraries obviously have no purpose, for it is difficult to conceive of their existing only to satisfy a feeling of pride or a desire for beauty. In this sense, then, libraries from their earliest days have necessarily served as communication centers.

It would be foolish to argue that libraries are primarily "stockpiles" or primarily "communication centers." The opportunity our topic offers is, rather, to analyze the directions libraries have been taking, and must take in the future, if they are to fulfill their prime obligation of knowledge transmitters, and to point out some of the activities this obligation involves and their relationship to the basic ones of collecting and conserving the material that makes dissemination and communication of knowledge possible.

This discussion is limited to three phases of the subject as it relates to science and technology. In the first of these it is possible to do little more than state the problem. This is the dissemination of information from the printed page to the scientist and researcher. The second and third points relate to the dissemination of information to the student and to the nonscientist.

Since most of the readers of this article are probably scientists, the problems involved in transporting data and other source materials from an unknown page to a laboratory test tube are undoubtedly of greatest interest. The vital importance of this process has been attested to over and over. During the past five years international organizations, societies, and universities have added page after page to the jumbled mass of technical literature, flowing ever more rapidly from the presses of the world. The necessity of putting it into better order is clear.

Traditionally, librarians have not concerned themselves to any degree with the aspects of documentation of most importance to the scientist. They have been concerned largely with the organization and cataloguing of monographic works. Periodical volumes and series have been put together by means of standardized procedures, with little thought or interest as to what might be included in these or

* Based on a paper presented in the Symposium "Operation Knowledge" during the Annual Meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE in Philadelphia, December 26–31, 1951.

how the information might ever again be brought to the light of day. Scientists, on the other hand, have concentrated largely on the analysis of serial publications. Their chief contributions to bibliographic organization have been the highly useful, but usually completely uncoordinated, tools such as *Chemical Abstracts, Biological Abstracts, Index Medicus,* their European counterparts, and thousands of minor abstracting and indexing services.

There is some thought in library as well as in scientific circles that a complete separation of bibliographical activities such as now exists is not only unavoidable but perhaps desirable. Even after some of the possibilities have been pointed out through international conferences and the activities of the Library of Congress and countless industrial libraries, there are those who maintain that the responsibility for finding the material remains solely that of the specialist. Others have realized that efficiency of communication demands joint action, that only through cooperation between the scientist and the custodian of his basic backlog of ideas can progress be made toward full and continuing utilization of the results of scientific research.

In general the librarian has used three devices to cover his contribution to the dissemination of the information caught between the covers of the books on his shelves. Of these, the card catalogue has proved more and more to be useful primarily in locating whole volumes when the user already knows of the existence of a specific book and its author. The subject approach through the card catalogue has been shown to be of value mainly to the undergraduate student and the layman and of relatively little use to the advanced student or researcher. The second device, classification, has aided the scientist in finding his way through the stockpiles, but its value has been hampered by two fundamental weaknesses. First, it can be applied successfully only to monographic material and therefore to a large degree it misses serials, periodicals, and other compendia. Second, its application to books is essentially linear in nature, with no way of leading the user to the books through the polydimensional reality of subject interrelationships.

The third device used by the librarian in the process of communicating knowledge from his stockpile has been based on his own knowledge of the contents of a selected group of volumes and sets, and his experience in going beyond these to the sources of information through the tools at his command. Except in the specialized libraries of industry and government this third device of individual reference service has not been effective in scientific fields because of the highly specialized subject knowledge demanded.

These three means which the librarian uses to ferret out information from his collections are closely related in many ways to the tools the scientist himself provides. The key to orderly solution of some of the ever-growing complexities of continued mass output of scientific literature may, therefore, well lie in a joint attack aimed at clear-cut, logical organization and documentation of the material. Perhaps it will be possible to cut down the present duplicative waste and still meet the minimum requirements of various subject interests. Several governmental agencies have already shown that libraries can efficiently extend bibliographic organization and documentation beyond the stereotyped limits of the monograph. Through a combined attack by the librarian and the scientist, the abstract service, the specialized index, the analysis of documents and reports, the card catalogue, and every other available method can be combined and utilized to their fullest. Mechanical devices and procedures can be employed, together with more traditional means, to ensure that the scientist has before him, clearly and promptly, all the results of past achievement that relate to his problem today.

To accomplish this the library profession, for its part, must attract to its ranks more and more persons who have been trained in the sciences and who have the vision to see that scientific progress without progress in documentation can lead only to chaos. They must also have the zeal to dig, like the archaeologist, through succeeding layers deposited by each generation; and they must have the patience to be content that a few of the pieces found will fit into a pattern that in turn may be used in the continuing development of man's mastery over nature.

Some phases of this topic have been studied by various groups, including the Special Libraries Association and the Chemical Literature Division of the American Chemical Society. Needless to say, only a few of the answers have been found. Continued progress depends on continued cooperation, and the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE and its affiliated societies should promote an active program aimed at effective future utilization of the results of past research and development. The scientist and the librarian each have contributions to make to the organization and thereby the use of scientific literature. Their combined and coordinated effort can far outweigh the contributions of each group working independently.

The second major phase of the dissemination of information from libraries is one that has received relatively little emphasis. This is the use of printed materials in the library by students. Although the subject has been approached in the past from both the point of view of the use of library materials as an aid in teaching and that of the importance of the knowledge of the use of books in professional life, students are graduating from departments of science and engineering in many of our colleges and universities with only the vaguest notion of how to locate information, and no conception at all of the importance of this knowledge for success in their chosen fields.

This is particularly true of the undergraduate. The graduate student, through work on his thesis and in advanced seminars, usually obtains at least a working knowledge of the literature in his field, if only through hit-or-miss methods that may leave serious gaps in his ability to handle the literature in all the areas in which his degree indicates competence. More often than not, however, the undergraduate leaves his alma mater with a handbook in his pocket and a dim idea that this, plus a few textbooks, will supply all his needs.

Educational procedures in colleges of engineering and science are gradually shifting emphasis away from textbook-lecture-memorization patterns toward those leading to analysis of problems and their solution on the basis of fundamentals and their broad applications. With this shift, unless the use of printed information is adequately taught, the student may actually be left weaker in his potential value as a scientist than when his stock in trade was a series of set patterns and formulas.

The place of the library in the educational program must, therefore, be broadened. It is not enough that it be used as a tool to disseminate the information the student will use in school. More important is its function of aiding the instructor in producing graduates who have the ability to continue learning after college, to enable them to build efficiently and well on the experience and knowledge of the past—not as it is represented in what has been placed in their heads through memorization, but as it exists on the pages of many thousands of volumes.

It is impossible to go into the philosophies, policies, and procedures that will bring education of this type into being. Where it exists or is evolving it is clearly a major responsibility of the library as a communication center to work with each school, division, and department within the college or university in planning an educational curriculum that will ensure that the student becomes familiar with all types of printed materials and their use in all types of situations.

Some believe that this objective can be accomplished through special literature classes conducted in each department. I seriously doubt the effectiveness of such a program, even with competent instructors. To mean something to the student, instruction and practice in the use of literature need to become a part of his professional courses, particularly those taken during his last few years. Only then will he see the material in its true perspective and realize its value for everyday use. This does not mean that the library staff can shrug its shoulders and pass on the responsibility to the instructor. A program of real value requires that the library staff work with the faculty in determining where, in the various courses, the subject matter, the printed materials, and the library facilities provide the best opportunity for giving the student the knowledge and experience he needs. The library staff should also be in a position to ascertain whether in a program of this sort, scattered as it is through many courses, there is an over-all coverage of all topics, without needless duplication. Finally, the librarian must know when and how the printed materials are used in every course. Without this information he cannot do a satisfactory job both of providing the stockpile in which the student will work and of aiding the student in his learning process as each new problem is approached.

I have purposely left until last the third area in which the library's collecting and dispersing activities need a great deal of coordination and development. The layman as the recipient of scientific information is a factor that is considerably emphasized today. Several years ago a prominent speaker at a AAAS meeting spent an entire evening on this topic and never once mentioned the library as an agent of carrying knowledge and understanding of science to the common man. It is possible that many scientists have been so closely tied to their university laboratories as to be unaware of the part some of our public libraries have played in this process or, more important, the opportunity that exists here for helping and encouraging the layman to understand not only developments in the world of science, but also their implications for his own world of tomorrow.

Most of the work done in the past in this area has been that of the public library and its technology department. Such departments have usually taken one of two distinct lines in their approach to technical literature and the dissemination of

information from it, but they have rarely combined them to any degree. In some cities the departments have been primarily technical reference libraries intended for the use of the scientist and engineer, with little effort to draw in the layman. In a larger number, the effort has been in the opposite direction, leaving the university library to serve the specialist. Too often the user of the latter type has been caricatured by the scientist as the crackpot inventor who religiously reads through the *Patent Gazette* each week in the hope of discovering an idea for a world-shaking invention.

No matter what the type of library, the opportunity is there, and if it is to be utilized fully the cooperation of the scientist is again demanded. No matter how well a book is written, it will not be read unless an interest is created in the subject and in its exposition on the printed page. Local sections of scientific societies can do much to create such interest by sponsoring, jointly with the public library, lecture series, radio and television programs, movies, demonstrations, or book reviews in local papers. The library with a ready-made reputation among scientists will have little difficulty in broadening its activities in these directions and in obtaining the aid of scientists in carrying them out. The university and college library can also profitably promote the reading of books on scientific subjects, not only among the students in its own school in all curricula, but through, for example, reading lists that can be used by admissions officers for the double purpose of interesting high school students in the sciences and in attending a specific institution.

All this depends on well-written, authoritative books on science, written in the language of the layman. If it is to be carried to its ultimate objective, however, it demands much more. It demands teaching of the sciences in high schools and colleges to the nonscientific student in such a way that his interest is not killed. On the contrary, he will realize that this introduction into science is not an end, but a base to enable him to understand the developments of science, a base upon which he himself can build. Such teaching will increase his interest and arouse his curiosity, and lead to continued learning beyond his classroom days.

If the library is to be more than a stockpile upon which such people may draw, it must be staffed with librarians who not only understand the subject matter they are dispensing, but who also understand the reader, and can provide him with material just beyond the limits of his previous knowledge, guiding him on to ever broader fields and greater understanding.

Can this be done in a day of comic books and television? I think it can. Not too many years ago the possibilities of continued learning and self-education were demonstrated over and over. If a man wished to become familiar with the subject matter of another field he bought some books and soon made the subject his own. Man still has that ability and that opportunity. Given the motivation to make a start, the satisfaction of his first successes will carry him on. Here, again, librarians need the help of scientists. We must stop the growing misconception that science is a magic world that can be understood only by a few supermen who have learned the secrets of Fourier Series and Bessel Functions and who have entered a holy of holies in which the mysteries of science are forever hidden from all whose brains are charged with less than a million electron volts.

Libraries, then, are more than stockpiles. They are more than repositories of scientific information to which only the initiated come for information. They are truly communication centers, with transmission lines to carry ideas and knowledge to the scientist and the engineer, to the high school and the college student as he prepares for his lifework, and to the lawyer, the merchant, the factory worker, and the housewife. People in every walk of life must comprehend the power that the mind of man and the laws of nature may exert over the products of nature, if these products are to serve and not enslave him, and are to meet the needs of a society that man himself controls.

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THE ELECTRIC RESISTANCE STRAIN GAUGE

SINCE 1938 the field of experimental stress analysis has been greatly stimulated by the advent of the resistance strain gauge—an inexpensive device about the size of a postage stamp that will accurately measure surface deformations to a few millionths of an inch. Further, these measured strains may occur in a ten thousandth of a second, and the gauge will follow them with excellent fidelity. The impact upon mechanics research made by this measuring device can be deduced when one realizes that 600,000 of them were used during 1951.

The earliest recorded observation of the fact that the resistance of a wire changes when it is stretched is attributed to Lord Kelvin, who in 1856 reported this and other information in a paper published in the *Proceedings of the Royal Society* (Fig. 1). His experiment showed that both copper and iron had increased resistance to current flow when stretched, and that for the same deformation the resistance of the iron wire increased more than that of the copper. In 1917 Bridgman published the results of an experiment by means of which he measured the change in resistance brought about in a conductor that had been subjected to hydrostatic pressure. Carlson, in 1930, used lengths of unsupported stretched wires to measure deformations occurring in a concrete dam. In 1935 Hull, of General Electric, applied a coating of carbon to a thin piece of paper, then glued the paper to material that was to be deformed. He measured the change in resistance that occurred as the carbon strip was stretched or compressed and interpreted his measurements in terms of strain. These experiments and devices were the forerunners of the bonded resistance wire gauge invented in 1937 by Simmons at the California Institute of Technology. Arthur C. Ruge, of Massachusetts Institute of Technology, further developed the gauge, and it was given the name SR-4 in deference to the inventor and the developer. Others who have had a part in developing the gauge are De Forest, Clark, and Tatnall.

In its simplest form, the SR-4 consists of a length of wire one thousandth of an inch in diameter bonded in a close zigzag pattern to a thin paper base and connected to suitable electrical conductors. Such a gauge can be glued to a piece of material and will change resistance when the material upon which it is mounted is strained. If the material is strained in tension, the gauge wire will be stretched and its resistance will increase. If the material is compressed, then the resistance of the gauge wire will decrease. That the tiny wire does not buckle when compressed is due to its being held rigidly in place by the glue that holds it to the paper base. In a sense, the glue is deformed and carries the wire with it.

Electric resistance strain gauges are made in many different sizes and shapes, some as small as one eighth of an inch in width by one sixteenth of an inch in length. Several different types of gauges are shown in Fig. 2. The gauge on the left in the illustration has three elements arranged in rosette fashion. By means of this gauge, strains in three directions can be measured simultaneously, and from them the principal strains (i.e., the largest and the smallest strains at the point in question, which, incidentally, occur at right angles to each other) can be determined mathematically. The gauge shown in the upper right-hand corner has its felt protective pad raised so that the arrangement of the wire grid may be seen.

When a wire is stretched it becomes smaller in cross section as a result of the Poisson effect, and because of the increased length and reduced cross section its resistance to current flow tends to increase. Conversely, when in compression, the wire shortens, at the same time becoming larger in cross section, and resistance to current flow tends to decrease. If the above reasoning is carried out mathematically, and the change in resistance is computed for a given lengthening or shortening of the wire, the change in resistance is not in general the same as that obtained by experiment. In his paper, Kelvin makes note of the phenomenon and says:

> I had made previously various experiments on copper wire alone, and on iron wire alone, in which I attempted to eliminate the effects of elongation and narrowing, and had very nearly established, for the case of iron wire at least, that the augmented resistance due to tension, either temporary or permanent, is a very little more than can be accounted for by the change of form. As, however, I have other experiments in progress, by which I hope to be able to show for a single metal the absolute effect on its specific conductivity separated perfectly from any influence on the resistance of the conductor occasioned by a change of its form, I defer in the meantime giving more details of investigation on this subject.

Apparently he did not find the time to continue his strain-resistance experiments, although he did later report the effect of stress on the magnetism of iron and steel wire (an avenue of investigation that might lead to another method of measuring strain). During the decade 1856–66, H. Tomlinson prepared a series of papers, all duly published in the *Proceedings of the Royal Society,* entitled, "In-

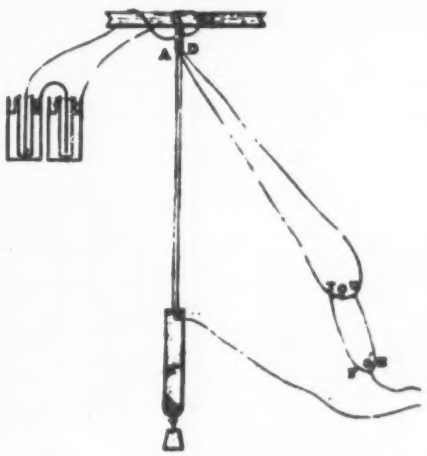
fluence of Stress and Strain on the Physical Properties of Matter." One of Tomlinson's most interesting observations is that not all wire exhibits a positive strain-resistance characteristic—i.e., resistance increasing as the wire is stretched and decreasing when compressed. Among exceptions he noted is nickel. When nickel is stretched, its resistance first decreases, then, as it continues to be stretched, its behavior reverses and it increases in resistance.

In recent years, tests have been conducted on many types of wire. These tests have verified the work of Kelvin and Tomlinson and in addition have supplied information on new materials. One type of wire made of a copper-nickel alloy, because of its insensitivity to temperature changes, has been found best for gauges that are to measure slowly applied strains. Isoelastic wire, which is made from a commercially available alloy that was developed for its property of constant elasticity over a wide temperature range, has been found to have higher sensitivity to strain than the copper-nickel but is also a great deal more resistance-sensitive to temperature changes. It is used to measure strains that occur in a few thousandths of a second, since the temperature of the material to which the gauge is attached usually will not change a noticeable amount during such an interval.

The changes in resistance that occur when the gauge is strained are quite small relative to the initial gauge resistance. Thus, if the gauge resistance is 500 ohms, a representative value of the change that might occur would be of the order of 1 ohm. The most common methods of measuring such changes in resistance are by means of either a Wheatstone bridge or a potentiometer. The bridge is most often used for static work because, with it, resistance changes that may be caused by temperature effects can be balanced out. Because of its simplicity, the potentiometer is most often used for dynamic work. Commercial instruments that are designed to be used with strain gauges consist of a bridge or a potentiometer connected to electronic

as an alteration experienced by QCD, has been indicated. If, however, a deflection is observed, in such a direction that the moveable electrode must be moved to some point P in the part OD, it is inferred that the ratio of the resistance of ABQ to that of QCD has been increased; or on the other hand, if such a deflection as requires a motion of the moveable electrode to a point P′ in OA, the resistance of AB has been diminished relatively to that of CD.

Fig. 39.



150. As an example, I shall describe an experiment on the relative effects of tension on electric conductivity in copper and iron wires. Two pieces of stout copper wire, A, D, were each twisted into a loop which was made fast by solder; a couple of inches towards one end of each wire being left free from the twisted part. These loops were put upon a strong hard wood peg about ¾ of an inch diameter, at a distance of about ¼ of an inch from one another; and to their lower ends were firmly soldered fine iron and copper wires (strong enough

* In the galvanometers which I have used, the two needles of the astatic combination are of similar material (pieces of the same steel wire, tempered brittle), and the lower one is a little longer (perhaps by about $\frac{1}{5}$) than the upper. Both are magnetized to saturation, and consequently the lower preponderates and gives its

5 D 2

FIG. 1. Lord Kelvin described (*Proc. Royal Soc., London* [1856]) an experiment which established for copper and iron the relationship between mechanical strain and electrical resistance. A photocopy showing his apparatus and a portion of the first paragraph of his report is reproduced above. During the decade following publication of Kelvin's experiment, Tomlinson studied and reported the strain-resistance characteristics of a great many materials. (Reproduced by permission.)

amplifiers which increase the small changes in gauge voltage to magnitudes that will cause the deflection of either a rugged galvanometer or the beam of a cathode-ray tube. A means of converting the measured changes in resistance of the gauge to changes in strain is provided by a constant known as "gauge-factor." This constant, supplied by the manufacturer, relates the unit change in length of the material being deformed to the unit change in resistance of the gauge and is obtained by a sampling process during a "run" of gauges. By many tests, some conducted at the National Bureau of Standards, the error in the determination of the constant has been found to be within $\pm$ 1 per cent.

The uses to which the SR-4 has been put are varied and interesting. One of the most important applications has been in conjunction with aircraft design. It is now standard practice to attach gauges throughout the structure of experimental aircraft before the outer surfaces are put in place. Wires are run from the gauges to a central position, and instruments are connected by means of which simultaneous measurements of strains throughout the aircraft can be obtained during flight tests. While undergoing test, rockets and guided missiles often have strain gauges attached throughout their structures, and strain information is sent from a transmitter within the missile to receiving stations on the ground.

Strains have been measured on the rapidly moving blades of turbines and on the slowly expanding surfaces of storage vessels under pressure.

An application which illustrates the versatility of the gauge and one with which I have had experience is the measurement of deformations on the surface of a gun as a projectile goes through it. This action is much like that of an ostrich swallowing an orange. A bulge occurs in the gun tube at the point where the projectile band makes contact. The band is the ring of soft metal, usually copper, that is firmly attached rearward of the projectile and performs the functions of sealing the gases behind it and of engaging the rifling to produce a stabilizing spin. Figure 3 shows the trace of the beam of a cathode-ray tube that has been deflected by the signal from strain gauges attached to measure changes in circumference of a gun tube. The upper strain pattern is from a gauge located near the gun breech and is illustrative of the surface deformations that occurred as the projectile was beginning to move and while it was still traveling

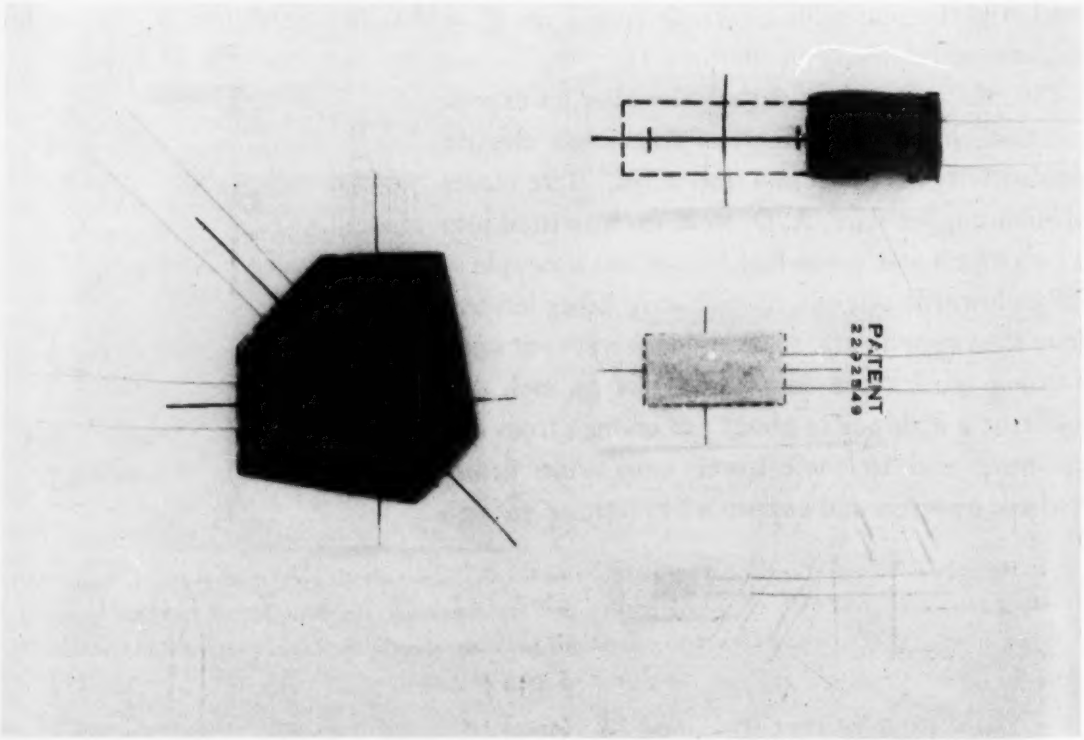


FIG. 2. Full-scale photograph of various types of resistance strain gauges. The three-element gauge at the left can be used to determine principal strains. The gauge at the upper right has its protective cover partially removed to show the configuration of the strain-sensitive wire.

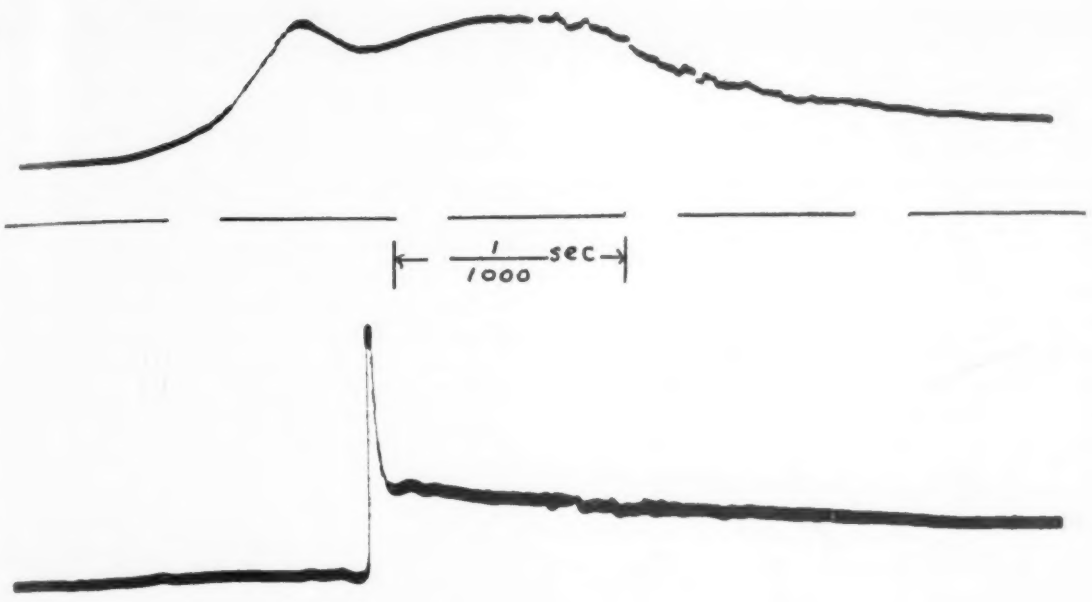


FIG. 3. Strains that occurred on the surface of a gun tube during firing, as recorded by means of resistance strain gauges. Pattern at top obtained from gauge near breech; pattern at bottom from gauge near muzzle. Maximum strain was of the order of 1000 microinches per inch. (Photographs made at Purdue University and reproduced by permission of Watertown Arsenal Laboratories and Army Ordance Department.)

rather slowly. The first part of this strain pattern exhibits the smooth rise and fall of strain caused by the rotating band as it passed beneath the gauge. The second rise and fall of strain was due to pressure produced by the gases of the burning gunpowder. It will be noted that as the energy of the powder was expended, the gun tube regained its original shape.

The lower strain pattern illustrates the deformation of the tube that occurred at a point one inch from the muzzle—a point at which the projectile was near maximum velocity. Here the strain caused by band pressure occurred very rapidly, since its duration (approximately 1/10,000 sec.) is a function of band width, gauge width, and projectile velocity. The slowly subsiding strain occurring after the projectile passed the gauge was again caused by the decreasing pressure of the powder gases—indicating in this case that the gas pressure was not zero at the time the projectile emerged from the gun.

In its applications, the SR-4 strain gauge has touched nearly all phases of engineering and physics. It has given the experimenter a means of seeing into structures and machines as they are being deformed by actual use and has supplied information that is enabling the designer to come ever nearer to the ideal.

It would be unfair if a discussion of the gauge did not give credit to the electronic art which has to a great extent been responsible for the wide application of the gauge. Without the aid of electronics, the small and often rapid changes in voltage generated by the gauge could not be amplified and recorded. Indeed, if the electronic amplifier had been available to Kelvin, the resistance gauge as it is now used might have been a reality in 1856.

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SCIENCE AND THE ARMY EDUCATIONAL PROGRAM*

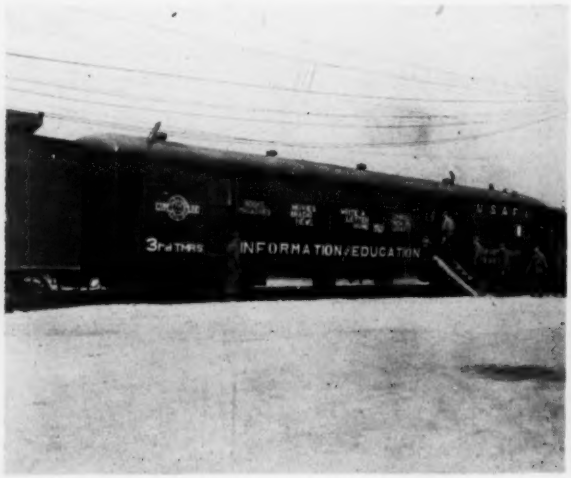
THE development of the citizen-soldier in the American Army is not concerned wholly with his duties as a member of the armed forces, for he is still understood to be primarily a civilian, who will eventually return to his former way of life. Although the avowed purpose of the Army Educational Program is "to increase the efficiency of the Army by raising the academic level of its personnel," the realization that modern combat requires a more intelligent soldier must also be felt by the soldier who will return to civilian life, so that he can adjust himself without too much hardship. And although the Army has been criticized for dulling an individual's mental reflexes, those who take advantage of its educational program are relatively better equipped for a more rapid understanding of, and reorientation to, civilian life.

The failure of many of Army personnel to readjust themselves following release from military service must be attributed to the inadequacy of their preparation and training prior to their entry into the Army. Much of this may have been the result of poor local school systems or lack of proper parental guidance. Actually, the cause—and the probable cure—can only be determined on a personal and a community level, where parents realize their obligation to correct the conditions that cheat their children out of their rightful place in society. Hospitals at Fort Bragg (North Carolina) and Valley Forge (Pennsylvania), where the Army Educational Program was instituted, have made a four-month survey of previous training and geographic origin of their patients. The results have revealed that sections of the nation that would normally be considered as having low educational standards were counterbalanced in other respects by sections supposedly high in this regard. Ironically enough, many men who came from the poorly educated sections showed an amazing desire to take advantage of the Army's educational facilities in order to achieve a higher degree of knowledge, whereas a good proportion of the men who had had access to superior educational facilities appeared to lack incentive for acquiring additional knowledge—at least within the immediate period of their hospitalization.

In order fully to understand the Army program, so that judgment may be accurately passed upon it, it is necessary to give a brief description of the four academic levels in the program. The first, or basic, level is designed for those men who have not reached the fifth grade, or who cannot read or write English. The group includes not only the comparative illiterates of the nation, but better educated aliens, whose lack of knowledge of the English language did not keep them from volunteering to fight on our side. Since this level is considered of great importance, training is accomplished on duty time, and during the first three quarters of 1951 it resulted in the presentation of 20,258 certificates to soldiers who had been illiterates or volunteer aliens with language difficulties.

The second, or intermediate, level carries the soldier through the eighth grade and prepares

* U. S. Army photographs.



USAFI mobile rail car of the 3rd TMRS Troop Information and Education Section at Taegu, Korea. Walter A. Andrews (Brooklyn), Ellis J. Heslop, Jr. (Standish, Mich.), Robert E. Felton (East Grand Forks, Minn.), and Robert I. Johnson (Presidio of San Francisco) enjoy the facilities of car shown at left.

NCO of X Corps traveling TI&E team explains various GED tests and courses offered by USAFI to privates with the 937th FA BN, north of Inje, Korea.

those who have not had sufficient previous training for entrance into high school. Of the four levels this particular group received the fewest number of certificates, a total of 4397 having been awarded. This fact suggests that the vast majority of men in the service had already achieved this degree of schooling.

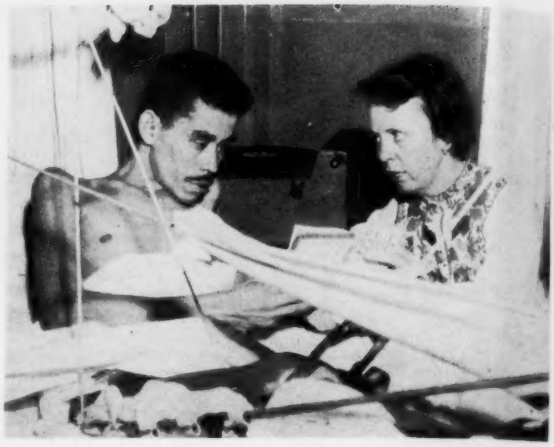
The third, or high school, level is by far the most important unit, both from the standpoint of student participation and from the results accomplished. At this level no diplomas are given, but practically all states have granted either high school diplomas or high school equivalency certificates. The soldiers take these courses in their leisure time and have found that the development of their special talents, along with their understanding of the usual required studies, results in a measurably improved ability to face the problems that are apt to confront them. The number of men who passed high school General Educational Development Tests successfully totaled 34,901 in the period ending September 30, 1951, and is convincing evidence of the tremendous success of the program. The fact that this phase of Army training was taken while the participants were off duty augurs well for the future national welfare. It is encouraging to find that the ambition to learn and to advance has not been stifled, but has been carefully stimulated.

On the fourth, or college, level the main requirement is the GED Test, which qualifies a man on the basis of his high school diploma or his first year of college work. The men who are accepted are then allowed to take courses than can be applied toward a college degree, if they decide to work in that direction upon their separation from the Army. The most outstanding men are selected for enrollment in civilian universities, where they specialize in subjects that have pertinence in their particular branch of the service. In this manner, many men are able to start careers in engineering or some other scientific field, while at the same time they gain further knowledge in the phase of work that will prove of maximum value in their military service. The number of men who passed college GED Tests was 6420; these are the most highly educated participants in the educational program.

At all four levels there was a total participation (third quarter of 1951) of 243,265 soldiers—a figure that demonstrates the ambition of the young men who are enrolled in the Army to improve their

educational status. The number, which is constantly increasing, also reveals that the Army realizes its duty to the nation, not merely as an organization of defense through military means, but also as an institution that must train men for the pursuits of peace—the ultimate goal of the military organization.

Educational possibilities are also offered to those who are not concerned with the four levels of the program. Among them are the USAFI (United States Armed Forces Institute) courses, which are well and widely known throughout all branches of the service. These consist of some 300 subjects and approximately 6000 educational courses in cooperating colleges and high schools throughout the country. They are constantly changing and range from purely academic subjects to such technical work as electricity. They have proved extremely popular with men of all interests. There were (as of September 1951) 76,430 soldiers enrolled as students in this type of educational self-improvement, and such correspondence courses have helped countless numbers of these men to find a career upon their return to civilian life, to improve their status in the work in which they were engaged before entering the service, or to improve their performance in the job to which they were assigned while in the Army.

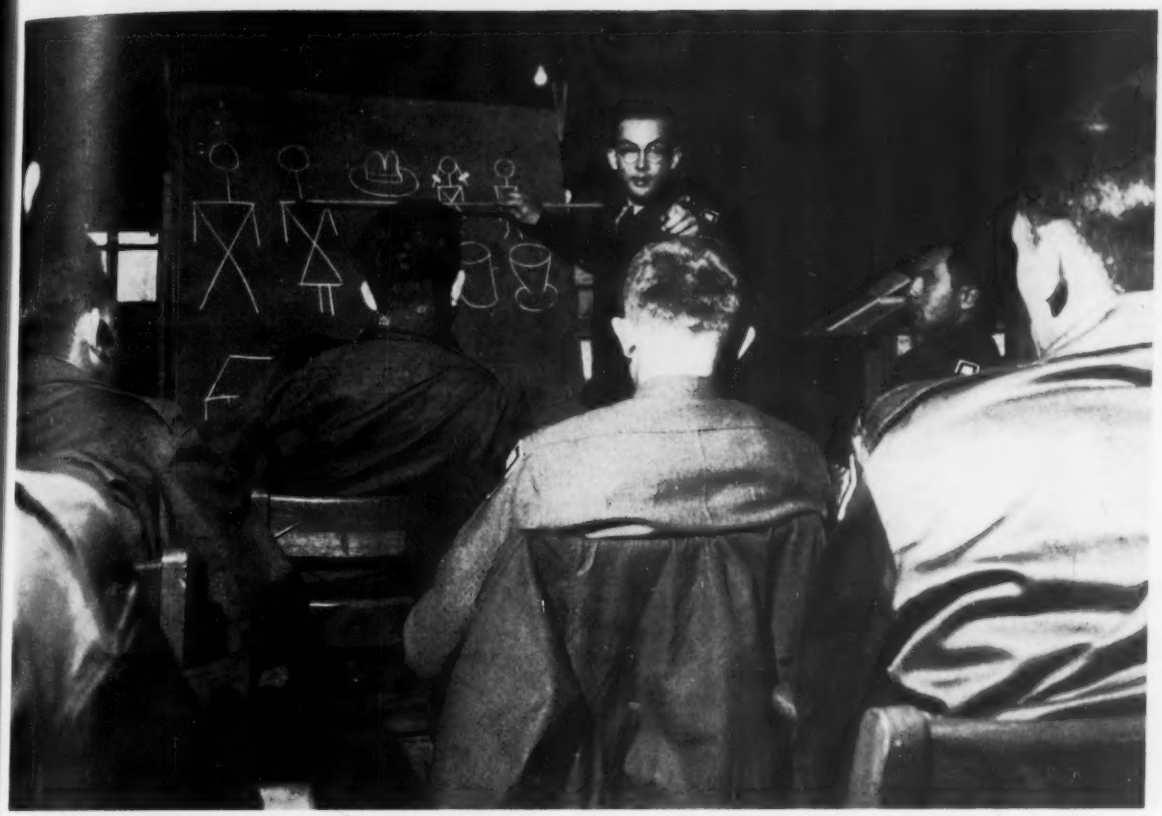


Although too weak to hold a textbook, a Korean casualty, Juan José Illa Valetín, of Santurce, Puerto Rico, studies English at Brooke Army Hospital, Fort Sam Houston.

At Army Education Center in Salzburg a soldier from the 567th Transportation Car Company learns the fundamentals of acetylene welding under the supervision of an English-speaking instructor from the faculty of the (Austrian) Technical and Vocational High School.

Educational manuals have been used in group study courses given during the soldier's free or duty time. For the conference method, which is generally employed, 1142 military and 1320 civilian instructors are being utilized. This type of instruction, in which there was an enrollment of 62,992, was usually presented three to five evenings a week by men well trained in their specialties, and it has given students an opportunity to learn new material or to refresh their knowledge on subjects that they felt would be of most benefit to themselves and to their work, at present or in their planned future. The Army has set up a testing system partially to enable those men who have not had a high school education to discover how they stand. In addition, there is an Advisement Program, with both military and civilian assistance, which is designed to help the soldier achieve the necessary academic level. On the highest level of education there is Residence Work, which is jointly sponsored by eighty-seven cooperating colleges and universities to the extent that there are 4539 soldiers enrolled as students.

On an international scale, the effect of these cooperative higher learning centers has been tremendous. For example, the University of Maryland has sixty or more centers in Europe, with an enrollment approximating 5000 students; and at the Pentagon Building there are about 1000 more soldiers enrolled in the Maryland program. Other areas that have soldiers enrolled as students while they are on overseas duty are the Far East (under the direction of the University of California), with thirty-



Alien enlistees at Fort Devens, Massachusetts, in English class of the special Language Qualifications Unit.

six centers; the Caribbean (under Louisiana State University), with six centers; and one center each in Hawaii (under the University of Hawaii) and in Alaska (under the University of Alaska). All the figures that have been given undoubtedly have been increased during the time that has elapsed since the date they were compiled (December 1951) and the date this paper was submitted (March 1952). However, they are truly indicative of the significant fact that, in general, the American soldier has no intention of allowing his education to be impeded by circumstances of a temporary nature, so long as the Army will provide the opportunity to continue the pursuit of knowledge, be it technical or general in its concept. (There has, of course, been some interference with this normal program in Korea.)

At the Army installations at Fort Bragg and Valley Forge, the percentage of men who were interested in the educational program was approximately the same as that for the entire program. The soldiers who knew that they were to be confined to the hospital for a reasonably long period showed the highest degree of eagerness to take the USAFI courses. Most illuminating was the fact that, aside from the men who needed nonscientific subjects for diploma purposes, the largest percentage of the patients selected scientific courses, and for those who possessed little formal education, the technical fields seemed to have a pronounced fascination. Once they started studying the subject of their choice, they seemed to forget their problems and turned their minds toward the mastery of the knowledge that the books and the supplementary material contained. Apparently they were able to visualize the possibility of at last finding a place in a world in which few opportunities had been open to them, and that through scientific or technical endeavor, they might acquire usable skills and the confidence necessary to face the future. Many of these students (particularly at Valley Forge Army Hospital) knew that they would be discharged following their stay at the hospital and were extremely anxious to learn as much as was available in some specialty that could be put to practical use immediately upon their return to civilian status.

At Valley Forge, students were able to make use of another important Army educational facility, the Post Library, to broaden the scope of their learning. Fully equipped with the latest scientific journals, as well as with many of the newest books,

Instructions in the use of a cutting torch being given at Fort Lewis, Washington, in an off-duty vocational training class in welding.

the library gave each soldier a chance to explore the field of his interest and to discover the significant advances and unsolved problems on the expanding frontiers of science and technology. With the war behind them and a new world before them, the vast majority of these wounded veterans at both hospitals had a solid foundation in education either to continue as soldiers or as returned veterans. More and more men were beginning to grasp the opportunities offered them, as they comprehended the fundamental values of general education and of scientific training. The Army is doing its part to extend the work of the local school; now the decision rests with the individual. Guided by scientific leaders and progressive educators, the Army has started along a path that can lead to almost unbelievable attainment of an ideal—a citizenry trained not simply for the military defense of our nation, but for the more constructive pursuits of future peace.

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BOOK REVIEWS

ONE WORLD

Geography in the Making: The American Geographical Society, 1851–1951. John Kirtland Wright. xxi + 437 pp. Illus. $5.00. Published by the Society, New York. 1952.

THE American Geographical Society was founded in New York in 1851, and now on its centennial its history has been written by John Kirtland Wright, who was the director of the society from 1938 to 1949. There are 382 pages of text, not counting appendices, bibliographical notes, and index, and it is significant that of these pages nearly half are devoted to the years 1915–35, during which Isaiah Bowman, late president of The Johns Hopkins University, was the director. It is significant because under Dr. Bowman's directorship the society began its distinguished research career. The years before Bowman are treated in five chapters, which deal chronologically with the presidencies of Bancroft, Hawks, Grinnel, Daly, Low, Peary, and Huntington, and the years since Bowman began his directorship, in eight.

The main title of the book is *Geography in the Making*, for Dr. Wright has done more than write a history of the American Geographical Society from 1851 to 1951; he has illuminated the whole development of American geographical studies, governmental, academic, and educational.

The story of the American Geographical Society begins with a succinct account of New York City in the fifties and of the actual founding of the society by a group of merchants and bankers whose world-wide interests made geography useful to them. Geography was then important because it was immediately practical.

By the seventies of the nineteenth century the enthusiasm that had led to the founding of the American Geographical Society had waned. The study of geography had little reputation in the United States; though the society was recognized abroad it was scarcely known at home. At the second International Geographical Congress, held in Paris in 1875, the American Geographical Society was represented by an American physican long resident there. A Chicago newspaper said in 1874:

> No part of the endowments of Harvard or Yale is devoted to its [geography's] encouragement; . . . so that the Smithsonian Institution and the archives of the topographical Engineer Corps at Washington represent pretty nearly all the encouragement given to a branch of knowledge most worthy of the attention of the greatest scientists. . . .

Yet in 1876, Judge Daly, who had become president of the society in 1868, was able to say in his annual address that at no time since the "great age of maritime discovery . . . of the fifteenth century" had interest in geographical discovery been so great. It was the period of Livingstone and Stanley in Africa and of the *Polaris* expedition.

At the time, in spite of the Chicago newspaper's account, Arnold Guyot was teaching at Princeton and Daniel Coit Gilman at Yale. In 1872, Gilman had given a favorable report to the society on the extent of geographical activity in the surveying of various parts of the United States, and recommended a National Topographical and Hydrographical Survey, which was subsequently started by the U. S. Geographical Survey.

Toward the end of the century popular interest in scientific geography waned again. There was no revival till the polar explorations of Peary in the first decade of the twentieth century and the outbreak of the first world war. The latter, especially, led to widespread academic revival, which coincided with the appointment of Isaiah Bowman as director of the society in 1915. The attention of the organization was immediately directed toward research, the results of which are contained in some ninety books and maps published since 1915. There had been but forty-six publications, mostly pamphlets, between 1851 and 1913.

Dr. Bowman's interest in South America led to the study of the geography of Latin America as a whole. Of some fifty or sixty books and maps published between 1915 and 1936, fifteen deal with one or another aspect of the geography of Latin America. Two of the books were written by Bowman himself and are important contributions to the literature of geography. More important, though, than the particular areas of research opened up by the society in the period was the fact that Bowman was able to persuade a considerable number of Americans that there was more to the subject than the preliminary surveys of explorers in unknown regions. The ample bibliography appended by Wright to his history demonstrates the variety of subjects legitimately subsumed under the name of geography. The support thus given to a wider view of geography than had hitherto prevailed helped new departments of geography then being formed in the universities and colleges of the United States.

With the present interest in geography, which is the consequence of two world wars and of the world-wide political and economic concerns of the American people, the development of the subject in the United States has come full circle. The present role of geography in education and in government bureaus is owing, in large part, to the effectiveness of the American Geographical Society in the latter part of its history. Dr. Wright's review of the history and of American geography ought to help stabilize the subject in the useful role which it has played throughout its whole history, from Eratosthenes and Strabo to the present day.

The writing is clear and interesting; the illustrations are adequate; and the author has told his story of geography in the making with a multiplicity of anecdote

about presidents, directors, explorers, professors, editors, and librarians, who throughout the century have contributed to the growth and to the influence of the American Geographical Society.

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FOR LABORATORY TECHNICIANS

Diagnostic and Experimental Methods in Tuberculosis. (2nd ed.) Henry Stuart Willis and Martin Marc Cummings. xxv + 373 pp. Illus. $10.00. Thomas, Springfield, Ill. 1952.

WITH the advent of the newer antituberculosis chemotherapeutic agents and with the advantages offered in the newer surgical approaches to pulmonary tuberculosis, the need for early and accurate diagnosis has become more evident. The new edition of *Diagnostic and Experimental Methods in Tuberculosis,* if widely circulated and utilized in general hospital laboratories throughout the country, should substantially decrease the diagnostic errors and aid in early diagnosis. Even in today's modern hospital laboratories, errors in diagnosis in relation to tuberculosis occur all too frequently. On the one hand, the laboratory errs in calling many cases tuberculosis which are definitely not, and, on the other hand, the diagnosis of tuberculosis is delayed too often because the culture techniques used are not sufficiently accurate. The careful, concise, and detailed directions for culture of the tubercle bacillus for animal inoculation should be an excellent guide to laboratory technicians. Of particular value are sections discussing the pitfalls in laboratory diagnosis. It would have been more helpful, however, if the authors had included some of the practical details of the culture of tubercle bacilli—the ones that are only gained through wide experience (such as not screwing the cap too tight on the culture tube so some oxygen may enter). Such refinements in technique as this may make a significant difference in the percentage of positive cultures obtained. Only slight reference is made to the Middlebrook hemagglutination test, and no reference at all to Maillard's complement fixation modification. These are as yet of doubtful practical value, but because of the wide publicity associated with them, a more detailed discussion of the theoretical background behind these procedures and of the possibilities offered with future refinement of the tests would have been useful.

Amyloidosis is still an all too frequent complication of tuberculosis. For this reason, a more critical evaluation of the Congo red test in tuberculosis should have been given. It is true that the authors mentioned the inadequacies and dangers of the test, but these were not sufficiently stressed. Some institutions have completely discontinued the use of Congo red because of fatalities associated with it. Furthermore, the test is of little or no diagnostic value in the one instance where it is of importance, namely, in amyloid nephrosis. The reasons for this probably should have been discussed in this particular section.

The section on animal care will be extremely valuable in those general hospitals that have had little or no experience with these procedures. The authors stressed the subcutaneous inguinal inoculation region as a site of preference. Others, however, particularly Feldman, prefer the subcutaneous inoculation site over the sternum. It might have been well to mention some of the other sites used by different investigators.

The importance of handling the surgically resected pulmonary specimen properly, both in pathologic and bacteriologic examination, is quite evident today. It would seem, therefore, that it would have been wise to include a section describing the proper handling of this material, so that the maximum amount of information might be obtained both for the benefit of the patient and for the compilation of statistical results for the evaluation of future prognosis and treatment. In fairness to the authors, however, it must be recognized that much of this material has only recently been reported, and the book undoubtedly must have been in press before ideas began to crystallize along these lines.

Despite these relatively minor omissions, there is no other source where one may find data as comprehensive and as accurate, in regard to the laboratory diagnosis of tuberculosis, as in this book. Every laboratory will find it useful.

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COUNTRY OF THE BIG MUDDY

Up the Missouri with Audubon. The Journal of Edward Harris. John Francis McDermott, Ed. xv + 222 pp. Illus. $3.75. University of Oklahoma Press, Norman. 1951.

IN THE summer of 1843 Edward Harris, amateur ornithologist and gentleman-farmer of Moorestown, New Jersey, accompanied his friend John James Audubon on an expedition up the Missouri to the Yellowstone. The diary which Harris kept in detail until the return trip, when the daily entries diminished to occasional jottings, is given in full. Other writings of Harris bearing on the trip appear in the appendices.

It had long been a cherished wish of Audubon to make the acquaintance of the country and creatures beyond the Mississippi. In 1842 this desire was focused by need for specimens for the octavo edition of *The Birds of America* and especially for the publication on the mammals. Plans were accordingly made for the trip which started in the spring of 1843.

Accompanying Audubon and Harris were three assistants; one was the artist Isaac Sprague, some of whose work appears in the plates. The party of five left St. Louis on April 25 in the *Omega,* the steamboat of Pierre Chouteau, Jr., and Company (American Fur

Company). Although the trip up to Fort Union at the mouth of the Yellowstone was a record run of a little less than seven weeks, so many stops were made for refueling and for negotiating the sand bars and vanishing channels that frequent sorties could be made by the members of the party to observe the country, animals, plants, Indians, and trappers, and to shoot birds and mammals, including the buffalo. These experiences were carefully recorded on the trip up and during the stay at Fort Union from June 12 until August 16. The return in a mackinaw boat was leisurely; the party arrived in St. Louis on October 19.

The introduction and footnotes by the editor, an authority on the history of the area, add immeasurably to the interest of the record. Many times notes giving Audubon's account of an incident recorded by Harris amusingly reveal the vast difference in the personalities and outlook of the two friends. Thus Harris estimates that four boats which they passed were carrying 1000 buffalo hides, whereas Audubon says 10,000; at a fort which they visited Harris comments at length on the destitute condition of its traders, but Audubon notes that the men were mostly engaged in playing cards and backgammon.

A helpful map, excellent and varied contemporary illustrations, lists of birds and mammals collected, an index, and pleasing format add to the value of this faithful picture of the Missouri country and its inhabitants in 1843.

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ADVANCES IN ALGOLOGY

The Fresh-Water Algae of the United States. (2nd ed.) Gilbert M. Smith. vii + 719 pp. Illus. $10.00. McGraw-Hill, New York. 1950.

IN THE years that have elapsed since the first edition of this admirable book appeared in 1933 there have been notable advances in the study of the fresh-water algae. Much fundamental work has been done on the structure, development, reproduction, physiology, and ecology of these forms. In the fresh-water habitats of this country many additional genera have been found, some of them new to science, some of especial interest or significance. Many additional species have been described, and their distribution, which in some cases seemed to be markedly restricted, has been found to be much more extensive. Furthermore, changes in classification have been indicated, and the relationships among these algae have been clarified as fundamental work on the detailed morphology, the detailed life histories, and the distinctive pigments has brought growing recognition that the essential structural and physiological characteristics provide dependable bases for classification.

In this second edition these advances in our knowledge of the fresh-water algae are effectively incorporated. In these seventeen productive years Professor Smith has actively continued his own investigations, kept up his notable familiarity with the rapidly growing literature, and maintained close contact with the other active workers in this field. As a result (fortunately for the many botanists and algologists who have depended on the first edition), the second edition continues to maintain the authoritative position of this valuable book.

In the present volume the advances in this field are reflected in the extension of content, the changes in organization, and the additions to the illustrations. The main text, thoroughly revised, has been extended to 636 pages in contrast to the previous 625, the comprehensive key, comprising 537 numbers instead of 431, has been increased to 23 pages from the former 19, and the bibliography, even though drastically revised, has also been increased to include the recent literature. Yet these increases are compensated for by condensing the table of contents from three pages to one and reducing the index from 28 pages to 15 by omitting the species names, with the result that the present book with its 719 pages shows an increase of only three pages over the total of the first edition. There are eleven chapters instead of the nine of the previous edition; the first three, revised from the three sections of the previous introduction, cover such general and introductory matters as the nature, classification, and evolution of the algae as a group, as well as the distribution, occurrence, collection, preservation, and methods of study of the fresh-water forms. In the detailed, specific consideration of the several groups each of the seven main groups has been raised to the status of a division from the previous rank of class—as, for example, Chlorophyta instead of the previous Chlorophyceae—and the order of sequence has been completely changed, since it now begins in Chapter 4 with the Chlorophyta (formerly Chapter 7), then passes to the Euglenophyta, which were the last chapter of the first edition, and in Chapter 6 under the Chrysophyta includes the Heterokontae, Chrysophyceae, and Bacillarieae, which previously occupied Chapters 4, 5, and 6. Then follow the Phaeophyta and Pyrrophyta, Chapters 7 and 8, and the sequence ends in Chapters 9 and 10 with the Cyanophyta and Rhodophyta which, in the first edition, began the series.

Together with this reorganization, the book has been extensively revised and much new material has been interpolated, one of the notable changes in treatment being the listing of the species of each genus with references to the sources where complete descriptions of each may be found. Two new chapters are included. Chapter 7 on the Phaeophyta presents a brief general account of the distinctive features of this almost exclusively marine group of some 200 genera, with a short account of *Heribaudiella,* the only one of the four fresh-water genera known to be represented in the United States. Chapter 11, on Groups of Uncertain Position, covers the Chloromonadales, with especial emphasis on recent work on Gonyostomum and Merotrichia, and the Cryptophyceae with its growing representation in the Cryptomonadales and Cryptococcales.

Among the new material incorporated in the book an addition of especial value for the student is the inclusion of a section briefly but effectively covering Chara, Nitella and Tolypella of the distinctive though aberrant Charophyceae, now placed in the Chlorophyta as a class with rank equal to the long-established and representative class of the Chlorophyceae. Also indicative of the expansion of material is the insertion of additional orders, such as the Colaciales in the Euglenophyceae and the Chrysosphaerales in the Chrysophyceae, and of additional families such as the Micractinaceae and Dictyosphaeraceae in the Chlorococcales, the Dichotomosiphonaceae in the Siphonales, the Coccolithophoridaceae and Prymnesiaceae in the Chrysomonadales, the Naegeliellaceae in the Chrysocapsales, and the Dermocarpaceae in the Chamaesiphonales.

In classification many changes have been made in conformity with recent developments. The distinctive assemblage of Cladophora, Rhizoclonium, and allied genera in the Cladophoraceae is removed from the Ulotrichales and given coordinate rank as the order Cladophorales, and the Vaucheriaceae, formerly in the Chlorophyceae under the order Siphonales, have been removed to the Xanthophyceae in the Chrysophyta, adjacent to the family Botrydiaceae in the order Heterosiphonales. As an example of the thorough taxonomic revision, we may note in the Chrysophyta the order Heterococcales, a large assemblage which comprises more genera and species than the other orders of the Heterokontae combined. This order has been revised in the light of recent work to include, of Pascher's ten families, the seven known to be represented in this country, one of these being the Mischococcaceae, which previously was classified in the order Heterocapsales, whereas of the four families that previously represented the Heterococcales in the first edition, only the Chlorotheciaceae still retains its position here, the Ophiocytiaceae being merged in it, the Halosphaeraceae being dropped out, and the Botryococcaceae disappearing with the removal of *Botryococcus* to the section of doubtful Heterokontae. Similarly, the division Pyrrophyta has been thoroughly revised in the light of recent work, the earlier inclusive Dinoflagellatae, which now compose the class Dinophyceae, being reorganized into four orders which are treated in detail; the small but distinctive class of the Desmokontae being inserted to accommodate the genus *Exuviaella*; the Class Cryptophyceae, formerly included here, is now, in the light of recent work, relegated to the groups of uncertain position in Chapter 11.

The numerous illustrations, an essential and valuable feature of the book, successfully complement and support the text, being on the whole even more effective than in the first edition. In all there are 559 illustrations, an increase of 110 figures beyond the previous total; also in numerous cases new and improved figures have replaced the earlier ones, and there are many instances in which the illustrations, through more effective inking or printing, are more sharply and clearly defined than were the same figures in the first edition. Most of the new figures fully meet the high standards consistently maintained by Professor Smith in his publications, but there are some, such as Figure 194 or Figures 289–295, contributed by other workers, which fall below these standards in that they are rather crudely drawn or coarsely stippled and lack any indication as to degree of magnification. Among the newly included illustrations the figures contributed by R. H. Thompson are notable for the precise portrayal of significant details, the perfection of draughtsmanship and the clarity of differentiation which distinguish them as the most admirably accurate and exquisitely executed illustrations that have enriched and embellished the literature of algology in many years.

The meticulous pointing out of typographical and other errors, that overworked device by which the reviewer vaunts his own pre-eminent perspicacity and demonstrates his perceptive page-by-page perusal, is rather pointless in the case of a book as outstandingly excellent as this. To this reviewer there is no detriment but rather a certain piquancy in "cylopharynx," "Oncobrysa," "Phorphyrosiphon," and "Caldophora." And "Pleurogasterl" has the charm of a Germanic term of endearment. Even the reference on page 626 to Figure 545 of *Merotrichia capitata* as *C. capitata* carries no confusion, although it is rather disconcerting when referred to Skuja 1932 for its description to find no 1932 publication in the six Skuja references given in the bibliography.

In sum, this second edition admirably fulfills the expectations of all who have awaited its publication and represents a significant and valuable contribution not only to algology but also to science.

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INSIDE STORY

When Doctors Are Patients. Max Pinner and Benjamin F. Miller, Eds. xiv + 364 pp. $3.95. Norton, New York. 1952.

When Doctors Are Patients is an extraordinary book, originally conceived by Dr. Pinner as a series of essays by physicians dealing with their own diseases. What was to be of especial interest was the influence of a disease on the patient and of the personality of the patient on the disease. There are few case records available which contain detailed subjective analyses of the problems connected with serious chronic afflictions or potentially fatal disease. Although this book was intended primarily for physicians, psychotherapists, and others connected with the care of the sick, it has an enormous amount to offer the layman.

The physicians are, in the main, specialists in various branches of medicine and the illnesses discussed cover a wide range of diseases. The writing is uniformly excellent, lightened frequently by touches of humor—from what reservoir of courage one can only imagine.

In fact, one finishes the book with a feeling of amazement at the fortitude, the adaptability, and the lack of self-pity shown by these people who have been subjected to the most disheartening and depressing physical and mental disabilities. Not only is there much-needed advice for other physicians in their relations with patients, but there is a moral lesson for everyone in the discovery, invariably made, of the essential values of life and the ultimate standards for happiness, however little, that may be available to them.

From the point of view of a healthy person, the adjustments these doctors have made to their illnesses are well-nigh incredible. For all continue to practice their specialties to the limit of their capabilities, and all have come to terms with an existence which, one might think, is, in many cases, little better than no existence at all. But it is that little which makes all the difference. To read of Dr. Darling's remarkable effort to control his epileptic seizures is to have a glimpse of what can be done for a devastating illness with intelligence, understanding, patience, and painstaking observation.

This book should go far toward increasing the understanding of both physicians and patients of the innumerable problems connected with disease.

RICHARD B. BERLIN

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SOVIET SCIENTIST

Russia's Lomonosov—Chemist, Courtier, Physicist, Poet. Boris N. Menshutkin. viii + 208 pp. Illus. $4.00. Princeton University Press, Princeton, N. J. (Published for the Russian Translation Project of the American Council of Learned Societies.) 1952.

SCIENCE (**115,** 407 [1952]) reports that there were 11,255 books published in 1951, of which 722 were classed as scientific. Assuming that book presses will turn at the same rate this year and provide us with two scientific books and 29 other volumes every day, the need for a tract such as *Russia's Lomonosov* is not apparent.

Nowhere in its pages does Lomonosov come alive. Judging from this record, his impact on science was insignificant and can in no way be compared with those made by such contemporaries of his century as Franklin, Rumford, or Lavoisier.

Lomonosov seems to have done little original work. His description of the transformation of work into heat had been expressed some years previously by Bernoulli. In physics and mechanics he followed closely ideas expressed by Christian Wolf. From Boyle he obtained the idea that it was necessary to study minute particles with the help of mathematics, physics, and chemistry. His electrical experiments are said to have been "of outstanding significance." This may have been so, but it is impossible to judge from Menshutkin, because he tells of nothing except some experiments in which Lomonosov helped G. V. Richmann duplicate experiments by Franklin and Dalibard. We are also told that Lomonosov made observations of the northern lights "all his life," but he wrote only two paragraphs of a book which was "very large in its conception."

In chemistry, the "realization of the labors of many years" turns out to be merely the construction with state aid of a factory for producing glass beads and glass tile for mosaics. Again, it is indicated that Lomonosov's 1741 *Principles of Mathematical Chemistry* was "a work of great import," but a few paragraphs later we learn that it remained unfinished and had no influence whatever on the history of chemistry. Lomonosov appears to have been a great starter but a poor finisher. There is no justification for Menshutkin's calling him the father of physical chemistry.

Lomonosov was a courtier, if courtier be defined as politician and intriguer. As a man, he cuts a poor figure in constantly intriguing through his patron Shuvalov, groom of the bedchamber, for promotion in the Academy and for other unearned preferment and honors. Some of these favors he won by eulogizing Empress Elizabeth. Nor was he objective, as a scientist or historian should be, in his attitude toward Peter the Great, whom he constantly eulogized. Even Menshutkin admits he did "not touch on the darker aspects" of that career.

As a poet Lomonosov appears in no better light. Lines which are said to be "remarkable for their expressiveness" arouse no emotion.

Instead of chemist and physicist, Lomonosov was a dabbler and an imitator; instead of courtier, an intriguer; instead of poet, a poor carpenter with words.

This book may be of some slight value for one reason. Author Menshutkin stated in 1937 that "temperatures are now observed in the stars which are measured at tens of thousands, even millions, of degrees; *temperatures absolutely unobtainable on earth.*" This statement should be recalled at that time in the future when scientists of the Soviet Union claim credit for having been the first to achieve nuclear fission.

RALPH F. WOLF

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ONE WITH THE APES?

Swartkrans Ape-Man, Paranthropus crassidens. Transvaal Museum Memoir No. 6. Robert Broom and J. T. Robinson. ix + 123 pp. + 30 figures. $5.60 plus postage. Transvaal Museum, Pretoria, Union of South Africa. 1952. (Order from Stechert-Hafner, New York, allowing eight weeks for delivery.)

ROBERT BROOM did not live to see this third and last of his men-ape monographs come off the press. The report on Plesianthropus from Sterkfontein appeared early in 1949. A few months before, he had unearthed the giant-toothed australopithecine at Swartkrans, a mile to the northwest. Work on the present volume was not begun until he had visited America to give a personal report on the progress of the excavations, which he owed in part to financial support from the University of California African Expe-

dition. Honors awaited him in Washington and London, and the demand for public lectures along the way in both countries was heavier than even his tough constitution could stand at the age of eighty-three. He returned to Pretoria a sick man, forced himself to complete the last section, and wrote "Finis" to a long life's work. The manuscript was seen through the press by its joint author, J. T. Robinson, the Cape-trained anatomist who was Broom's right-hand man and on whom has fallen the responsibility for carrying on the excavations.

The monograph, besides representing the authoritative description of the first *Paranthropus crassidens* material, records Broom's final verdict on the status of the entire group of South African men-apes—from Dart's *Australopithecus africanus* found at Taungs in 1924, through the romance of Broom's own discoveries at Sterkfontein and Kroomdrai, and Dart's *A. prometheus* from Makapansgat, to the Swartkrans finds. The book, therefore, cannot but be an essential item on the shelves of all those investigating human origins.

The style and presentation are typically Broomian. Drawing on a profound knowledge of the vertebrates—acquired first under the rigorous discipline of the anatomy laboratories at Glasgow, furthered by his study of monotremes and marsupials while a practitioner in the back lots of Australia, and greatly extended after 1903 in South Africa, where his interest in fossil reptiles and amphibians led to the identification of over fifty new genera—he presents a wealth of comparative data in proof of the significance of *crassidens* and his kind. Nor is the discussion free of the fierce rejoinders with which Broom demolished the arguments of those who dared to challenge the near-human status of the creatures for which their discoverer has done battle for a quarter of a century.

Broom's considered opinion was that the men-apes form a group of higher Primates, approaching man in many characters, not closely related to the higher anthropoids, but probably allied to an earlier type of anthropoids. He believes that there lived in Oligocene and Miocene times a group intermediate between the Old World monkeys and the anthropoid apes, that they gave rise to the Australopithecinae, and that from them in the Pliocene period sprang early types of man.

Although the bulk of the book deals with *P. crassidens,* two sections are given to the jaw and teeth of the more advanced form, *Telanthropus capensis,* the exact status of which is still indeterminate.

Broom's almost uncanny ability to forecast with assurance what a particular missing part ought to look like was proved on more than one occasion by its later discovery. The same prophetic flair haunts the words of one of the last paragraphs he wrote: "Of course the longer we delay publication, the more discoveries we will be able to announce. . . . Quite probably in the next two years we may make so many new discoveries that a new Memoir will be called for. . . . So the present Memoir may be looked upon as only a preliminary account."

So it was no surprise to receive as recently as March 1952 the following personal communication from Mr. J. T. Robinson:

> Excavation at Swartkrans is going very well. In the last few weeks we have found numerous ape-man specimens, mostly in the shape of teeth. Two crushed skulls are, however, also among the booty, and several very fine mandibles, including a juvenile mandible which is almost complete. Another more fragmentary juvenile jaw is of an appreciably younger dental age than any ape-man specimen so far found—I estimate it at roughly three years. The first permanent molars are not yet really starting on the eruption process, and the two milk molars are in fine condition and hardly worn. A nearly erupted lower canine is indistinguishable in shape, size or anything else from a Bantu one in the same state of growth that we happen to have in the collection. Aside from many other differences, the canines of *Plesianthropus* and *Paranthropus crassidens* exhibit as great a difference in size and morphology as is known among all modern and fossil forms of man, including the australopithecines themselves.

The printing of this monograph shows a marked improvement over that of the previous memoirs. The blocks from Broom's own fine-line drawings have the quality of etchings.

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CONTROLLING THE SEX IMPULSE

Sex and the Law. Morris Ploscowe. ix + 310 pp. $3.95. Prentice-Hall, New York. 1951.

IN THE tedious transition from a state of nature to civilization, man's biological urge to reproduce his species has been, and is, the most difficult of all his instincts to curb and sublimate. Each new generation must learn afresh to conform to the imperious dictates (mores) of the social group, or pay the penalty for nonconformity. Some persons readily submit; others, for a variety of personal or social reasons, stumble or remain inept.

This sociolegal study deals with the general problem of sex in Anglo-American society, and the punitive restraints that have evolved in our dynamic culture in an effort to control the human sex impulse.

Judge Ploscowe, a well-known and widely read jurist, writes from firsthand knowledge of the problem in all its ramifications, as he has dealt with it in New York City. His treatment of sex and law falls naturally into two parts: (1) marriage and its related problems—annulment, divorce, illegitimacy, etc.; (2) deviant and forbidden sex behavior—fornication, adultery, indecent exposure, rape, homosexuality, sodomy, crimes against nature, prostitution, etc. These chapters are followed by a critical discussion of the psychopath-sex-offender laws in relation to crimes against children.

The author also comments profusely on the strange and contradictory origins of our existing laws regarding sex and points to the many dilemmas arising out of

differences between legislative and judicial opinion on many vital phases of the entire subject.

In the introduction, Roscoe Pound, formerly dean of the Harvard law faculty, renews his customary plea for (*a*) scientific lawmaking, and (*b*) the creation of a ministry of justice, with broad powers and competent personnel, to deal objectively with such problems as sex.

The book is well organized, clearly written, and thoroughly documented. A check list of leading books and articles on the various topics, together with the author's frank and courageous proposals for change, plus his familiarity with the sociological and research aspects of the problem, make the monograph an invaluable handbook for law-enforcement officers, prosecutors, judges, social workers, and penologists. Every thoughtful legislator should be familiar with it. It seems to this reviewer, also, that high school principals, deans of boys, and deans of girls should be motivated, if not required, to peruse it. Its implications for the counseling and character education of the American adolescent are tremendous.

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HISTORY OF COSMOLOGICAL THEORIES

Cosmology. H. Bondi. 179 pp. $4.50. Cambridge University Press, New York. 1952.

THIS very carefully written book describes the development and the present status of various theories attempting to understand our universe as a whole. After a brief survey of the aims and fundamental principles of cosmological studies (Part I), the author devotes considerable space to the detailed presentation of all information that may be of significance for the formulation of cosmological theories (Part II).

The third, and the most important, part of the book contains a mathematical discussion of existing cosmological theories. It begins with the theory of the expanding universe, which can be derived in almost identical form both from the classical Newtonian theory of universal gravity, and from the more advanced Einsteinian general theory of relativity. It is stated that the main defect of that theory lies in a large discrepancy between the age of the universe as derived from the observation of the red shift in distant galaxies (1.8 billion years) and the age of the earth as estimated by geological methods (3.6 billion years.)

The next section is devoted to cosmology based on Milne's kinematic relativity, which introduces the idea of kinematic and dynamic time scales. It is found that Milne's cosmology is also in difficulty because of the above-mentioned discrepancy between astronomical and geological age estimates.

The author indicates that the only cosmology which is free from that difficulty is the theory of the steady state universe developed by himself, T. Gold, and F. Hoyle several years ago. In fact, according to that theory, continuous creation of matter in space secures the permanence of the universe from minus eternity to plus eternity, so that the question of its age does not arise at all.

This is followed by a short discussion of the cosmological ideas of Eddington, Dirac, and Jordan, based on the analysis of universal constants and their possible variability in time.

Unfortunately this very excellent book suffers from a defect caused by the rapidity of scientific progress as compared with the slow process of book production: it has become out of date at publication. In fact, more than a year ago the revision of astronomical data pertaining to the measurement of intergalactic distances led to the conclusion that these distances are actually about twice as large as previously believed, thus raising the value of the astronomically estimated age of the universe from 1.8 to 3.6 billion years. This fact radically changes the evaluation of the relative merits of different cosmologies as given in the book.

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THE EVOLUTION OF SCIENTIFIC KNOWLEDGE

Cultural Sciences: Their Origin and Development. Florian Znaniecki. viii + 438 pp. $6.00. University of Illinois Press, Urbana. 1952.

THIS is the fifteenth book to be published by Florian Znaniecki, who is probably best known in this country for his part in the collaboration with the late W. I. Thomas on *The Polish Peasant in Europe and America.*

Like many others, Dr. Znaniecki is sensitive about the fact that social scientists are spurned as spurious not only by legislators and governmental administrators, but by many of their colleagues in the natural sciences as well. Comte, the founder of modern sociology, dreamed of a world that would be ruled by social scientists according to ethical values to be empirically determined as the best for humanity. Dr. Znaniecki, while disclaiming that his ambitions for social scientists (or "cultural scientists," as he calls them), are as audacious as were those of Comte, nevertheless confesses to the hope that eventually

> . . . the solution of all important human problems will be entrusted to cultural scientists, and that sociologists will assume the task of ascertaining how innovations of specialists in various realms of culture (including the realms of natural sciences and of techniques) can be cooperatively used by social groups of practical agents for the best advantage of humanity.

The book is heralded by the writer of its dust-jacket blurb as one to inspire "renewed hope . . . that man may yet save himself from the negative aspect of the Atomic Age . . . it is a book of promise for mankind." Actually, only a few pages at the conclusion of the book are written in this vein; the rest is devoted to outlining the history of the social sciences. Dr. Znaniecki

does not address himself to the problem of how the businessmen and political leaders are to be persuaded to abandon their hostility to social scientists and entrust "all important human problems" to their hands. There is little to inspire such a hope, beyond the author's simple expression of straightforward optimism and expectation that someday, somehow, such things will come about. The book, advanced by the publishers as "a beautifully lucid summary" of Dr. Znaniecki's study of the development of social science, seems to this reviewer to have fallen a little short of the claim.

Throughout most of the work, the author is preoccupied with the concept of *order*. He traces the early ideas of order among primitive peoples, pointing to the function of magic in preserving order or intervening in a natural order of events. Legendary figures, "culture heroes," to him are creators of moral order. Great conquerors and rulers, such as Alexander the Great, Justinian, and Augustus were creators of world order in historical times. Modern examples are Hitler, Hirohito, and Stalin, "three great hero creators of world order."

The origin of philosophy the author finds in the search for logical consistency and "coherent rational order among objects of knowledge." The beginning of science itself he sees in mathematics, the recognition of a conceptual order inherent in the unified system of nature. The development of astronomy and geometry, he declares, led to the conception of one universal, uniform, and measurable space, including all measurable objects.

Comte, it will be remembered, sought to unify all scientific knowledge by the discovery of one all-pervasive force, as for example, gravity. Though he remained convinced in his monistic philosophy, Comte never succeeded in discovering this unitary principle. Dr. Znaniecki seems to be advancing such a principle in his theory of order. The desire for order has led to the growth of larger and larger societies and the amalgamation of races and states. The search for order has inspired the founding of religions and reform movements and has led to the growth of philosophy and science. Finally, the search for the most illusive of all principles of order, that of the affairs of men, has led to the development of the cultural sciences.

Ideologies are advanced, developed, and discarded in the search for order. However, says Dr. Znaniecki, the expansion of an ideological system is not a historical necessity. "It is the result of purposeful actions," he writes, "individually initiated but collectively supported and continued. Leaders, heroes, makers of order, initiate ideological movements which are embraced and perpetuated by followers."

However, he does not explain why a particular leader, with a particular ideology, is accepted and gains a following at a particular time and place. Why this leader and not that one? Why this ideology and not the other? If we are to accept Dr. Znaniecki's theory, it would seem that each instance would have to be viewed as unique, the result of the voluntary action of an individual able to rally a following. It would seem at this point that Dr. Znaniecki's position is at variance with that accepted by the main body of sociology.

Albion W. Small, one of the founders of American sociology, at the turn of the century had already begun outlining the basic tenets of social science in America. Small characterized sociology as an "intellectual movement" which first of all included the realization that all social life is a part of the realm of cause and effect. Small, who was at pains to refute the free-will idea and the "great-man" theory of history, pointed out that "the content of human activity is the product, not of arbitrary fiats of human volition, but of intelligible causation; human volition itself is not arbitrary and uncaused."

Dr. Znaniecki's work is withal most interesting and intellectually stimulating, a valuable contribution to the advancement of a discussion now sadly neglected by too many social scientists momentarily turned specialist. An erudite scholar of social science, Znaniecki is rated by Harry Elmer Barnes as one of the few European sociologists who have had great influence in America. To the credit of Columbia University, Dr. Znaniecki was invited to leave his native Poland for a teaching position in the United States in the fall of 1939. It was in this way that he missed the advent of the Nazis, into whose hands he otherwise would have surely fallen.

ROBERT E. WILLIAMSON

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BRIEFLY REVIEWED

The Butterflies of Virginia. Austin H. Clark and Leila F. Clark. viii + 239 pp. $2.25. Smithsonian Institution, Washington, D. C. 1951.

FOR the past twenty years Dr. and Mrs. Clark have devoted most of their leisure time to the study of the butterflies of Virginia, visiting all the hundred counties in the state two or more times, at different seasons of the year, and collecting specimens of the more than 150 species of butterflies that occur in Virginia. The findings of their travel and research, supplemented by the observations of many voluntary cooperators and correspondents, as set forth in the present volume, constitute a rich fund of information not only for the professional entomologist but for the amateur collector of this unusually attractive group of insects.

The reader will find effective help, in identifying any butterfly he may chance to observe, by consulting the ingenious keys, prepared especially for readers who are not butterfly specialists, the color patterns on the wings serving as dependable guides. For each species the authors have recorded the time of year, the geographic location, the preferred food plants, the variations in color to which the species is subject, and many other details to guide the amateur to its proper name. In the case of the yellow swallowtail the variation in color pattern is so extensive as to be confusing to the casual observer. Fifteen or more photographic illustrations show the extent of its variation.

These observations covered more than 800 localities

within the state, with meticulous attention to the number of yearly broods and to the differences in habits and distribution of species with two or more broods, between the spring, summer, and fall broods. Evidence of the rather frequent occurrence of hybridization among butterflies, particularly between the yellow and orange species of the clover butterflies, *Colias philodice*, and *C. eurytheme*, and between the variants of the yellow swallowtails, is recorded.

The authors have in all cases noted the food habits, some species feeding promiscuously on a variety of plants, others feeding exclusively on one kind of plant—as, for example, the monarch on milkweeds, phoebis on cassia, and some of the fritillary butterflies on violets. Interesting details are given of the little-understood migration of the monarch, and on species like the buckeye that are summer visitors only and die out in winter. The plates showing photographic reproductions of all species are of unusual excellence, prepared by G. L. Hightower and F. B. Kestner, and an adequate index is appended of scientific names only.

The amateur devotee of butterfly lore might wish that common English names, so far as they are generally recognized, had been included in the index. For example, such names as monarchs, blues, angle-wings, fritillaries, hairstreaks, skippers, admirals, painted lady, mourning cloak, and swallowtails are quite familiar and might be looked for in the index.

E. V. Wilcox

Washington, D. C.

Nuttall's Travels into the Old Northwest. An Unpublished 1810 Diary. Jeannette E. Graustein, Ed. 88 pp. + 12 plates. $3.00. Chronica Botanica, Waltham, Mass.; Stechert-Hafner, New York. 1950/51.

Dr. Graustein has contributed importantly to the knowledge of the events and activities of Thomas Nuttall's life by discovering and editing his 1810 diary. As pointed out in the preface, most sketches of Nuttall's life have abounded in errors. Nuttall's carelessness about dates and other details was partly responsible. Although a reasonably complete and accurate account of his life was brought together in 1936 by Francis W. Pennell, many uncertainties still exist. The diary has removed some of them.

The book contains, in addition to a reproduction of the diary itself, a preface, introduction, several appendices, and numerous illustrations. The first section relates the many attempts that have been made to document Thomas Nuttall's life and indicates some of the difficulties encountered by Graustein in deciphering and editing the diary. Also presented in the introduction is a brief synopsis of Nuttall's life from his birth in 1786 until his death in 1859. This provides the background necessary for an understanding of the importance of the diary of 1810.

A faithful transcription of the diary is presented by the editor; faulty punctuation and misspellings of the original have been retained. The diary covers the period between April 12 and September 10, 1810. A few undated entries were made later, and one item was written late in 1811. As Dr. Graustein points out, the subject matter is chiefly biological, with frequent detailed descriptions of plants (usually in Latin) and lists of plants and animals. Notes appear on many subjects: Indian mounds, rocks, oil and mineral springs, goiter, and many other items of interest to Dr. Barton, close friend of Nuttall and sponsor of his travels.

Because of the numerous interlinear additions and footnotes in the original diary, plus the additional footnotes added by the editor for clarification, and the Latin plant descriptions, Dr. Graustein's book makes for slow, difficult reading. This, fortunately, is compensated by Nuttall's style and expression. Students of the history of biology will certainly want the volume as a library accession.

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Introduction to Mycology. J. A. Macdonald. x + 177 pp. Illus. $3.00. Academic Press, New York; Butterworths Scientific Publications, London. 1951.

There has long been need for an accurate introduction to the study of fungi briefer and less comprehensive than such meaty texts as those of Bessey and of Gäumann; and the author has sought to fill it with this book. To that end he has presented a simplified classification, a limited list of the type organisms, and, in controversial matters of interpretation, usually the one hypothesis or generalization that seems to him best supported. Although inevitably his choices are not always those that would be made by another author, none of them seems to show undue bias, and they add up to a fair presentation of the subject. Some, like the discussion of that peculiarly mycological phenomenon, the dikaryon, will help to dispel rather widely disseminated error; others, like the description of a sterile monosporic mycelium as homothallic, are less fortunate. The errors in statement of fact are neither numerous nor important, except that the false supposition that clamp-connections are present only in homobasidiomycetes seems to be a chief prop of the phylogeny presented.

Chesters, the author of the preface, states that the book "is written in a manner which brings it within the scope of the upper forms of school and of the interested lay reader." Most regrettably, what this amounts to is a rather unskillful writing down. The author has too often employed the short, simple declarative sentence—not one, but a long series of them—to the extent that the text suffers not only in style but in ability to retain interest. "Due to," used as though it were a compound preposition, is nearly as frequent and quite as irritating. Some of the illustrations would be acceptable as blackboard sketches; others would not. As an introductory discussion, the work is usable, but scarcely inspiring.

Donald P. Rogers

New York Botanical Garden

Hudson's Bay Trader. Lord Tweedsmuir. 195 pp. $3.00. Norton, New York. 1952.

THE son of John Buchan never intended his fascinating diary of a year in Baffin Land to be a book. He wrote it "for something to do; and also from an unwillingness to allow so much that was so strange, so amusing, and so exciting, to go entirely unrecorded. . . . Much of it was written with very cold hands . . . in snow houses along the trail . . . by lamplight at the Hudson's Bay Company Post . . . and in the tiny wooden cabin of a schooner."

Nor was his intent scientific. He was working for the Hudson's Bay Company, gathering furs and running a store. Yet his tale of the Eskimo life, of hunting and trapping in a country "all hard knocks and buffets," holds much of interest for the naturalist. He writes of bear, caribou, foxes, birds, walrus, seals, hares, and of "strange Arctic flora which grow in the shape of pincushions."

The life was a hard one but was full of peace and contentment. His account of it is, unwittingly perhaps, poetic. For instance, "the breaking crests lit a thousand candles of phosphorus" and, again, the "hills looked like gingerbread powdered with flour." Long summer days and the eerie dark of winter occasion other fine descriptions.

There are few personalities within the book (few people live in Baffin Land) but, such as there are, they are treated with gentle humor. Nature, in its forces, is the main actor; wind, snow, ice, and blizzards fill the pages. Many entries in the diary begin with the statement that nothing much has happened and then continue with accounts of dogs and sled treks and chats with the Eskimos. It presents a way of life that seems humdrum at the time but in retrospect becomes rare adventure.

MARJORIE B. SNYDER

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The Astronomical Universe. Wasley S. Krogdahl. xvii + 599 pp. Illus. $6.25. Macmillan, New York. 1952.

THE author must be congratulated on this excellent introductory text. Its usefulness is greatly enhanced by a large number of questions at the end of each chapter. There are a few minor points, however, where in my opinion the text could be improved. I feel that on the whole the author has catered rather too much to the mentally lazy student and in doing so has often sacrificed rigor in his statements. For instance, a statement such as "most stars are binaries" (p. 327) could easily have been put in more quantitative form. Another point is that the author often fails to state clearly how far the theories he discusses are generally accepted, or still subject to discussion as, for example, the theory of the origin of comets (p. 224).

I feel that Dr. Krogdahl could easily have introduced more mathematical formulas, perhaps in small type, since mathematical formalism is, in my opinion, an important part of the scientific method to which the author devotes an extremely interesting first two chapters, Chapter II showing how the scientific method is applied in astronomy to the orbits of the members of the solar system.

I regret the practically complete lack of references, which is intentional, and should have preferred the introduction of bibliographical notes, which are used so effectively in Chandrasekhar's books.

These minor criticisms are not meant to detract from the great merits of this text. Its subject matter is carefully chosen. Part I deals with The Solar System, Part II with The Anatomy of a Star, Part III with The Stellar Population, Part IV with The Organization of the Universe, and Part V with The Evolution of the Universe; three appendices deal with The Constellations, The Magnitude System, and Telescopes and Observatories. The book is excellently illustrated and contains six detailed star maps.

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Field Crop Insects. F. A. Fenton. ix + 405 pp. Illus. $5.75. Macmillan, New York. 1952.

THIS book covers essentially the subject matter taught by the author in a course on field-crop insects designed for students in agriculture. It is a fairly comprehensive elementary survey of the subject and should be a good text or reference book for students, county agents, and farmers. The first 158 pages give basic information on terminology, field-crop insect abundance, distribution and biology, insecticides and application equipment, physical, mechanical, cultural and biological control, plant quarantines, and pest control campaigns. Some informed readers may not entirely agree with all the author's statements on some of these topics.

The remainder of the book is devoted to brief individual discussions on the importance, biology, and control of the major insect pests of field crops. These summaries are grouped according to the parts of the plants attacked by the specific insects. This seems like a good arrangement.

A few of the summaries suffer somewhat from brevity, repetition, or omission of important factors in the application of control measures, and the efficiency of some of the methods given for the use of insecticides against certain insects is open to question. Occasionally, faulty grammar or choice of words obscures meaning, and there are a few errors in spelling, particularly of authors' names in the references given at the end of each chapter. In some cases more recently published and better references could have been selected.

The book is fairly up to date, but the status of information on insect distribution and insecticidal control is changing so rapidly that any publication pertaining to these subjects may be unavoidably somewhat obsolete by the time it appears in print.

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LETTERS

THE ABDICATION OF REASON

THE anonymous article "Cleared for Top Secret," in the March issue of THE SCIENTIFIC MONTHLY (**74,** 145 [1952]), deserves wide circulation, both in the United States and abroad. It should certainly open the eyes of all those who advocate the continuance of the "cold war" policy of the U. S. government as to the consequences of such a policy on the intellectual life of our country.

The author, a scientist of note, spent four months pleading with judges who had condemned him in advance. They found him presumptively guilty of "Communist ideas and . . . affiliations." He begged for hints as to the charges made by his unknown accusers. He spent many hours searching through his files for trivia that he could use in his own defense, even marshaling fifteen years of check stubs to prove that he had not given money to any causes the board might deem unacceptable long years after the donations. He sought out friends, acquaintances, and colleagues for letters, telegrams, and affidavits in his behalf. He took financial losses amounting to almost $3000 in time and money. Constantly throughout the period he worried about the future of himself, his sons, and his son-in-law in the event his appeal should fail.

Yet it is his mental state that is more disturbing than the events he recounts. He submitted to the board voluntarily—nay, obsequiously. He accepted with humility the fact that one cannot express his political views without jeopardizing his freedom to work in his own scientific field. At the end of his ordeal, he even wrote a letter to the board expressing admiration and gratitude!

That a scientist of note, as the author indicates himself to be, should cringe before such a board speaks volumes about the facist, police-state methods that were apparently taken for granted by the individual in question. That intellectual activity *can* so far abdicate its role, as it did in the anonymous author, we should no doubt have realized from the experience of Nazi Germany; but that the self-abasement of the scientist has progressed to this extent in our own country will doubtless come as a revelation to many people.

It is futile for the author of "Cleared for Top Secret" to plead the cold war in defense of his own attitude, as he betrays the scientist's freedom to work for peace and scientific cooperation among nations. The cold war is directed precisely against a country where scientific questions such as genetics, hydroelectric construction, peaceful uses of atomic energy, and linguistics are among the major topics of the day. It is a country, moreover, which is technically at peace, whereas our own country is not.

The fact that the Abraham Lincoln Brigade is the only organization mentioned by name in the article affords me the opportunity to mention that I am a member of the Veterans of the Abraham Lincoln Brigade. I am especially proud at the present time to be a Brigade member—no less proud, certainly, than to be a member of the AAAS.

It was, indeed, the same type of mentality, to which the author of "Cleared for Top Secret" yields, that found its full expression among the ranks of the followers of Franco and his Nazi and Fascist supporters. The whole world knows how the intellectuals in Spain and elsewhere rallied behind the Spanish Republic. If some of these "intellectuals" now would like to forget about having done so, all the worse for them, and all the worse for whomever else they may now admit as arbiters of their thoughts. The complete spiritual and scientific sterility to which we became accustomed in Fascist Italy, Nazi Germany, and Falangist Spain threatens to obliterate all intellectual activity in our country now. Just as Mussolini, Hitler, and Franco doomed the intellectual life of their countries, in the name of anti-Communism, the intellectual life of our own country is threatened under the same slogan. We shall have to look to others than those who are willing to crawl if science, as distinguished from mere technology, is to be kept alive.

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THE anonymous article "Cleared for Top Secret" is one of the most challenging articles to appear in recent issues. It fits into a disturbing pattern in these troubled times when scientists who express their political convictions learn to their sorrow that unquestioning acceptance of the status quo—even if this breeds sheer hypocrisy—is regarded as proof of loyalty to American institutions. The article also brings out very clearly a point which has long been stressed by many social scientists—namely, that natural scientists themselves are seldom unbiased when discussing controversial issues having social implications. Nor is this at all surprising. For how can any person who has been exposed to stereotyped indoctrination and interpretation concerning social issues during his formative years fail to reflect at least unconscious bias in his views as an adult?

Certainly the author has brought into bold relief the "either-or" fallacy of communistic and fascistic ideologies: the assumption that there can be no middle ground of intelligent *constructive loyalty* in the face of hysterical demands for blind allegiance to an uncritical attitude that could conceivably make a mockery of democracy. Let us all be devoted to the cause of combating subversives with every valid weapon at our disposal. But in our zeal to punish a small group of Communists we must be careful not to deprive a host of patriotic Americans of the constitutional guarantees of

freedom of thought and discussion to which they are justly entitled.

Perhaps the following quotation will summarize the problem quite effectively: "We are told that we must be afraid of Russia, yet we are busily engaged in adopting the most stupid and unjust ideas prevalent in Russia, and are doing so in the name of Americanism. The worst Russian ideas are the police state, the abolition of freedom of speech, thought, and association. . . . The heart of Americanism is independent thought. The cloak-and-stiletto work that is now going on will not merely mean that many persons will suffer for acts that they did not commit. . . . Far worse is the end result, which will be that critics will be frightened into silence. Stupidity and injustice will go unchallanged because no one will dare to speak against them. To persecute people into conformity by the nonlegal methods popular today is little better than doing it by purges and pogroms" (R. M. Hutchins. What Price Freedom? In J. Davis (Ed.), *Character Assassination.* New York: Philosophical Library [1950]).

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SIGNIFICANT SAMPLE

THE table contained in the anonymous letter on "Teaching Success vs. Research Ability" in the June issue of THE SCIENTIFIC MONTHLY (**74,** 374 [1952]) reveals also some positive relationships between research ability and teaching success.

Out of the seven A-grade researchers only one (=14 per cent) is rated below C as teacher. Out of the six B- and C-grade researchers four (=67 per cent) are rated as D or F teachers. Despite the small number of cases, this difference reaches the 5 per cent level of significance as determined by Arkin and Colton's formula.

This comparison looks very much like the follow-up results of many tests used for predicting vocational success.

EDWARD BAKIS

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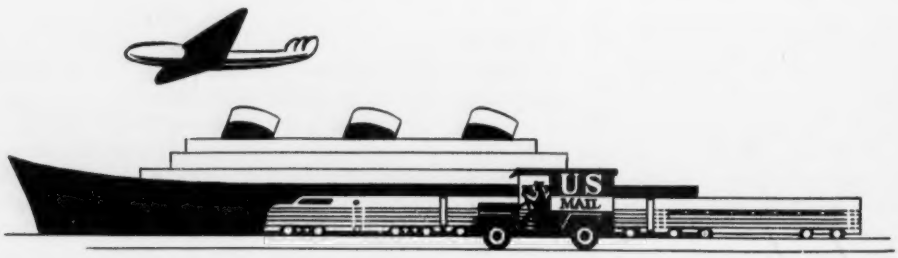
Sterling College

COSMIC RAY PHYSICIST

I know about chambers,
And counters and transfers;
I know my cross sections and know my ev's
And I weather showers
Where you can get wetter
The deeper you hide in Pb.

In voyages heroic
I make a great stoic
As I search in the emulsion for stars;
And things do get better
And warmer and cozier
When the aneroid records the last millibar.

The meson, the photon,
The neutron and proton;
None hide any secrets from me;
And I have stopped chasing
The wily neutrino.
That was just a mild case of mv's.

JOAQUIN A. GARCIA DE LA NOCEDA

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